

Identification of Risk-Based Remedial Goals

Iron Mountain Road and Bains Gap Road Ranges

Fort McClellan
Calhoun County, Alabama

April 2010

Task Order CK11
Contract Number DACA21-96-D-0018

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Final – Revision 2

**Identification of Ecological Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges**

**Fort McClellan
Calhoun County, Alabama**

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1.0 Introduction

Ecological risk assessments have been conducted at the Iron Mountain Road (IMR) and Bains Gap Road (BGR) Ranges at Fort McClellan (FTMC) starting in January 2002, as documented in the *Screening-Level Ecological Risk Assessment for the Iron Mountain Road Ranges* (IT Corporation [IT], 2002a) and the *Data Evaluation Report and Screening Level Ecological Risk Assessment for the Bains Gap Road Ranges* (IT, 2002b). The *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Iron Mountain Road Ranges* was completed in November 2002 (IT, 2002c), and the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* was completed in April 2003 (Shaw Environmental, Inc. [Shaw], 2003). Based on the results of the screening-level risk assessments (SLERA) and the problem formulation and study designs for the IMR and BGR Ranges, it was determined that a single baseline ecological risk assessment (BERA) would be appropriate to address the assessment endpoints identified in the problem formulations for both of these small arms range complexes. The fieldwork for the combined IMR/BGR BERA was accomplished in May and June 2003. The draft BERA for the IMR and BGR ranges was first reported in the *Draft Remedial Investigation Report, Iron Mountain Road Ranges* (Shaw, 2004). From January 2002 (when the IMR Ranges SLERA was first reported) until the present, numerous rounds of comments have been received by the Army from the various stakeholders at FTMC (i.e., the U.S. Environmental Protection Agency [USEPA], the Alabama Department of Environmental Management [ADEM], and the U.S. Fish and Wildlife Service [USFWS]), and revisions made to the SLERA, problem formulations, study designs, and BERA in response to those comments. The most recent iteration of the BERA conducted for the IMR and BGR Ranges (Shaw, 2008) reflected over eight years of reporting, analysis, negotiation, and consensus between the responsible parties and stakeholders. The IMR/BGR BERA in its current form indicated that one or more constituents in surface soil, surface water, and sediment have the potential to pose adverse effects to sensitive ecological receptors in the terrestrial and riparian ecosystems at the IMR and BGR Ranges.

Based on the results of the BERA, the need for ecological risk-based remedial goals (Eco-RBRG) was identified. In order to identify site-specific concentrations of the constituents of potential ecological concern (COPEC) that are protective of the sensitive receptors potentially present at the IMR and BGR Ranges, the various lines of evidence collected during the BERA were analyzed. Eco-RBRGs were derived from the various lines of evidence. These Eco-RBRGs are concentrations of COPECs in the various environmental media that are protective of the

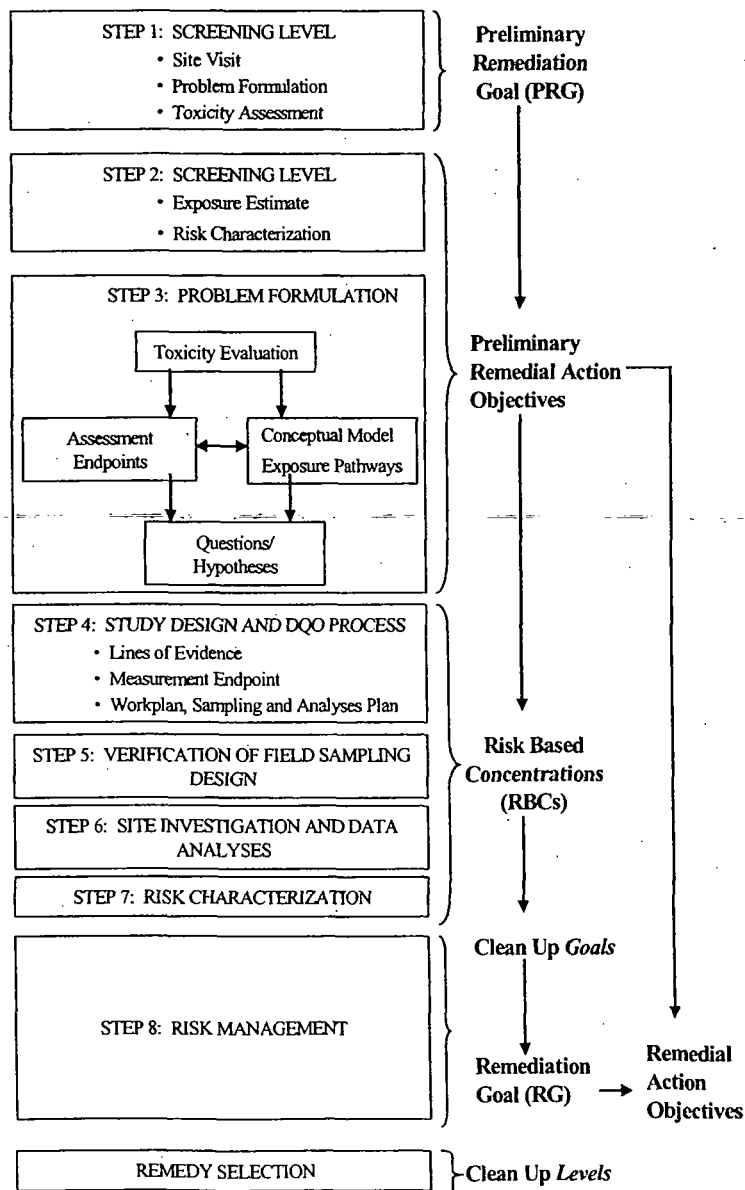
assessment endpoints described in the BERA. Because several lines of evidence were assessed for some of the assessment endpoints and COPECs, several Eco-RBRGs were also derived for these assessment endpoints and COPECs. The following sections describe the identification of the most appropriate Eco-RBRGs for each COPEC in each environmental medium at the IMR and BGR Ranges at FTMC.

2.0 Risk-Based Remedial Goals in the Comprehensive Environmental Response, Compensation, and Liability Act Process

The need for Eco-RBRGs is based on the results of the BERA. If a BERA identifies unacceptable risks, then the responsible party (the U.S. Army) is required under the National Contingency Plan to develop remedial alternatives protective of human health and the environment. The Army, in conjunction with the various stakeholders, establishes remedial action objectives (RAOs) for developing and screening remedial alternatives that may be necessary to address the identified risks. RAOs specify the contaminants, the media of concern, the potential exposure pathways, and the risk-based remedial goals (RBRG).

The development of RAOs progresses throughout the ecological risk assessment process (Figure 2-1). Initially, preliminary remediation goals (PRG), or ecological screening values (ESV), are developed based on readily available information, such as screening-level benchmarks published in the literature or chemical-specific applicable or relevant and appropriate requirements. The PRGs are modified as necessary throughout the ecological risk assessment process, as more information becomes available during the remedial investigation (RI)/feasibility study (FS), including baseline risk assessment. Final remediation goals are determined when the remedy is

Figure 2-1. The ERAGS 8-Step Ecological Risk Assessment Process and Position of Key Remediation Terms



DQO = Data Quality Objective

selected in the FS. RBRGs link the ecological risk assessment portions of the RI to the engineering aspects of remedial designs in the FS.

Key definitions in the process of developing cleanup levels are as follows:

Preliminary Remediation Goal (PRG) - Ecological PRGs are screening-level benchmarks or applicable or relevant and appropriate requirements identified early in the initial stages of site investigations, often at the work plan stage prior to commencement of RI/FS activities. They are the ESVs used in the SLERA. PRGs are based on readily available information and are generally not site specific. PRGs are used by managers to begin the screening and identification of remedial alternatives. As the RI/FS progresses, the PRGs may evolve to become final remediation goals (RG) by incorporating site-specific information.

Remedial Action Objective (RAO) - The RAOs describe what the proposed site cleanup is expected to accomplish. The RAOs, as defined in the National Contingency Plan, specify the contaminants, the media of concern, the potential exposure pathways, and the remedial goals (RG). For establishing RAOs protective of the environment, RGs must also specify relevant categories of receptors in the assessment endpoints from the BERA.

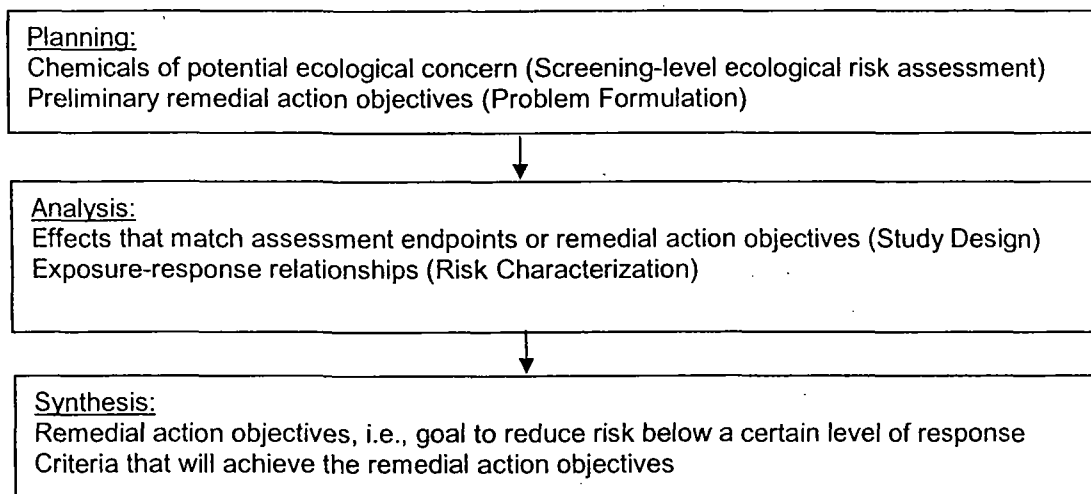
Risk-Based Cleanup Goal (or Risk-Based Remedial Goal [RBRG]) - This term is used to describe the site-specific risk-based media contaminant concentrations associated with an acceptable level of risk. These values are not modified based on remedy selection criteria. They do, however, reflect an element of risk management in that the concentration is deemed to be associated with an acceptable level of risk. RBRGs are selected by risk managers from a range of risk-based media concentrations associated with a specific level of risk. The RBRGs are identified from the results of the BERA and are associated with the assessment endpoints described in problem formulation. Methods for derivation of RBRGs are described in this report.

Cleanup Level - Cleanup level is a term used to describe the medium-specific chemical concentration corresponding to the level of risk identified to be attained by the selected remedy in the record of decision.

3.0 Development of Risk-Based Remedial Goals

The development of cleanup goals is based on the general process outlined in Figure 3-1 (Suter and Cormier, 2008). Numerical goals are typically derived with methods and data developed in the BERA. A cleanup goal expresses the level or concentration of a constituent in an environmental medium that is associated with a level of effect (response) in an ecological receptor that is considered to be acceptable. Cleanup goals are often based on site-specific information and the results of the ecological risk assessment's own unique problem formulation and study design. There is no one method to derive cleanup goals. Cleanup goals are established on the basis of methods used in the BERA and may include predictive risk analysis methods (i.e. food web modeling), toxicity testing of contaminated media, demographic information (i.e. bird population surveys or benthic invertebrate community analyses), and/or other supportive information. Any of the results from these methods may be used in a multiple lines-of-evidence approach. Agreement among site participants and stakeholders on the studies and information that will provide data for development of the cleanup goals is achieved at the scientific and management decision point in the study design.

Figure 3-1. Ecological Risk Assessment Process



The BERA is designed to provide data that relate observed adverse effects in environmental receptors to measured exposure concentrations in environmental samples. The interpretation of these data is the determination of toxicity values that relate chemical concentrations to potential effects. The following terms are used to describe the toxicity values derived in the BERA:

Apparent Effects Threshold (AET) – The concentration at and above which effects are always observed. Since all samples with concentrations of a COPEC at or above the AET have observed effects, there is good evidence that the COPEC, or another co-occurring COPEC or stressor, may be causing the observed effects.

No-Observable-Effect Concentration (NOEC) – The highest concentration at and below which effects are never observed. Since all samples with COPEC concentrations at or below the NOEC have no observable effects, there is strong evidence that the COPEC is not toxic at levels at or below the NOEC under those environmental conditions.

Lowest-Observable-Effect Concentration (LOEC) – The lowest concentration at which an adverse effect is observed. Often, some samples with concentrations between the AET and NOEC are toxic and other samples are not toxic. The LOEC is the lowest concentration of the COPEC in this range that has an observed effect. However, because some samples with COPEC concentrations above the LOEC are not toxic, the evidence that the COPEC is the cause of the observed effect is not as strong. The effects may or may not be related to the COPEC.

Predictive risk methods use calculated or modeled exposures compared to toxicity reference values (TRV) to predict hazard quotients (HQ). Some examples of predictive risk methods include food web modeling and tissue burden bioaccumulation modeling. The equations used to estimate risk can be rearranged and used to calculate a range of risk-based concentrations (RBC) that can be used to derive cleanup goals. Because the TRVs for a particular contaminant are often reported as no-observable-adverse-effect levels (NOAEL) or lowest-observable-adverse-effect levels (LOAEL), the application of these values in rearranged food web models will result in a range of RBCs based on NOAELs and LOAELs. This RBC range reflects the uncertainty in the TRV. Uncertainty can also occur in the estimates of the bioaccumulation factors, which express the degree to which contaminants accumulate in wildlife foods from abiotic media, and also in the exposure factors used to estimate wildlife exposures via food web interactions.

Toxicity tests are often completed in a BERA to quantify the severity and incidence of adverse effects. From these data, relative effects across a range of exposure concentrations can produce stressor-response relationships. Cleanup goals can then be identified as those exposure concentrations that bracket the acceptable ranges of effects. Depending on the type of contaminant, medium, and receptor, the descriptions of pertinent endpoints and terms used to quantify the response will vary appropriately (e.g., LOECs, NOECs, effects concentration for 10 percent of a population, effects concentration for 50 percent of a population, etc.).

Stressor-response relationships between the chemical concentrations in environmental media and the relative response in site receptors can also be obtained from demographic studies, such as

benthic invertebrate community studies, fish population or community studies, and mammal or bird census studies. The methods for developing cleanup goals from these studies are similar to those used for toxicity tests in that pertinent endpoints such as LOECs, NOECs, etc., are used.

Multiple Lines of Evidence. The occurrence of converging lines of evidence can serve to strengthen the basis of cleanup goals. Using multiple lines of evidence from the BERA reflective of the assessment endpoints in the RAOs can reduce uncertainty in the development of a cleanup goal. It should be recognized that not all lines of evidence carry equal weight in the decision-making process and not all have equal relevance to real-world conditions at a given site. A test conducted on laboratory organisms or with models that must estimate wildlife exposure has less relevance to actual on-site conditions than a demographic study conducted on site. A demographic study, unless it happens to show a clear gradient of effects across chemical concentrations, provides the researcher with less control and can be affected by confounding variables that hinder its ability to predict a cleanup goal. Toxicity testing is particularly useful in developing a dose-response relationship, because field samples of environmental media can be collected to target levels desired for testing in the laboratory. Evidence from the field (or other tests that may not have exhibited a dose-response relationship) may be used as multiple lines of evidence to support or validate cleanup goals developed by other means. The "Rule of Five" (Greenberg and Charters, 2005) is an example of a lines-of-evidence approach that divides the uncertainty range between the NOEC and LOEC into six segments by inserting five geometrically spaced nodes. The basic concept, however, is the exploration of the overlap between NOEC to LOEC ranges for the various assessment endpoints to select a point within the range of overlap based on the degree of certitude for each.

It is important to note that it is not necessary, nor is it USEPA policy, to systematically select the most sensitive RBRG when multiple RBRGs and multiple lines of evidence are available for a given COPEC in a given environmental medium. Rather, USEPA guidance recommends that Eco-RBRGs be selected from within the range of acceptable risk identified in the BERA. As stated previously, a weight-of-evidence approach has been taken with regard to selecting the most appropriate RBRG for each COPEC in the environmental media at the IMR and BGR Ranges at FTMC. As such, the various lines of evidence that have been developed for each COPEC in each environmental medium are discussed and qualitatively weighted to determine the recommended Eco-RBRGs.

4.0 Risk-Based Remedial Goals for Soil

The ecological endpoints that were investigated in the IMR/BGR BERA with respect to COPECs in soil were earthworm survival and growth, and adverse effects on omnivorous mammals and birds and invertivorous mammals and birds through food web interactions.

Earthworm toxicity tests (survival and growth endpoints) indicated that COPECs in soil at the IMR and BGR ranges may cause adverse effects in terrestrial invertebrates (e.g., reduced survival and/or growth). Additionally, the terrestrial food web model indicated that sensitive terrestrial receptors could experience adverse effects due to exposure to COPECs in soil at the IMR and BGR Ranges through food web interactions.

The results of the earthworm toxicity tests indicated that antimony is most likely not responsible for the observed effects in any of the earthworm tests. Adverse effects in earthworms (e.g., reduced growth) were observed at copper concentrations as low as 62.2 milligrams per kilogram (mg/kg), lead concentrations as low as 779 mg/kg, and zinc concentrations as low as 35.1 mg/kg.

The terrestrial food web model (using NOAEL-based TRVs and site-specific soil-to-invertebrate bioaccumulation factor [$BAF_{\text{soil-to-invert}}$] values) was used to predict soil concentrations that would be protective of the sensitive terrestrial feeding guilds found at these ranges. The food web model indicated that adverse effects to terrestrial receptors could occur when antimony concentrations in soil exceed 2.95 mg/kg, copper concentrations in soil exceed 267 mg/kg, lead concentrations in soil exceed 55 mg/kg, and zinc concentrations in soil exceed 215 mg/kg.

The calculated Eco-RBRGs for soil COPECs at the IMR and BGR Ranges ranged from 2.95 to more than 1,620 mg/kg for antimony, 61.4 to 16,200 mg/kg for copper, 55 to more than 15,600 mg/kg for lead, and 33.5 to 555,000 mg/kg for zinc. Potential Eco-RBRGs for soil COPECs are presented in the IMR/BGR BERA (Shaw, 2008) and are summarized in Table 4-1. It is important to note that these soil Eco-RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of the IMR/BGR BERA.

Table 4-1. Summary of Potential Ecological Risk-Based Remedial Goals for Soil

Measurement Endpoints	Soil COPECs			
	Antimony (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Terrestrial Invertebrate Survival and Growth				
28-Day Earthworm Survival NOEC	6.7	127	779	47.3
28-Day Earthworm Survival LOEC	17.9	334	2,310	63.9
28-Day Earthworm Survival AET	>1,620	509	15,600	139
28-Day Earthworm Growth NOEC	NA	61.4	760	33.5
28-Day Earthworm Growth LOEC	NA	62.2	779	35.1
28-Day Earthworm Growth AET	NA	334	6,820	72.8
Terrestrial Food Web Exposures				
Site-Specific BAF_{soil-to-invert} :				
White-Footed Mouse NOAEL	4.85	267	205	1,750
White-Footed Mouse LOAEL	48.5	350	1,680	193,000
American Robin NOAEL	2.95	850	55	39,000
American Robin LOAEL	14.8	1,140	147	555,000
Short-Tailed Shrew NOAEL	6.85	820	100	215
Short-Tailed Shrew LOAEL	68.5	1,185	800	173,000
American Woodcock NOAEL	12.2	11,870	105.5	46,500
American Woodcock LOAEL	61	16,200	280	550,000
Background Screening Values:	1.99	12.7	40.1	40.6
Soil RBRG Range :	2.95 - >1,620	61.4 - 16,200	55 - >15,600	33.5 - 555,000

4.1 Soil Ecological Risk-Based Remedial Goals Based on Terrestrial Invertebrate Endpoints

The terrestrial invertebrate community forms a critical link in many terrestrial food webs and constitutes a food source for many omnivorous and invertivorous birds and mammals. Terrestrial invertebrates also perform an important function in the degradation of organic matter in soil through their bioturbative activities. Terrestrial invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the terrestrial invertebrate community was identified as an important ecological resource at FTMC.

Earthworm toxicity tests were conducted as part of the IMR and BRG Ranges BERA in order to determine the bioavailability of the soil COPECs to terrestrial invertebrates, determine the bioaccumulation potential of the soil COPECs in terrestrial invertebrates, and determine the concentrations of COPECs in soil that could induce adverse effects in terrestrial invertebrates. Specifically, the adverse effects (measurement endpoints) that were studied in the earthworm toxicity tests were mortality and growth. The results of the earthworm toxicity tests and the corresponding concentrations of the soil COPECs are summarized in Table 4-2.

Because the earthworm toxicity tests indicated that antimony was most likely not a causative agent in the adverse effects observed, the derivation of an Eco-RBRG for antimony is subjective. However, an Eco-RBRG for antimony, based on earthworm survival, can be identified as 17.9 mg/kg. This antimony concentration in soil is the LOEC for earthworm survival determined in the earthworm toxicity tests. No adverse effects that could be attributed to antimony in soil were observed in the earthworm growth tests.


An Eco-RBRG for copper in soil can be identified as 334 mg/kg, based on earthworm growth and survival. The copper concentration in soil of 334 mg/kg represents the LOEC for earthworm survival and the AET for earthworm growth determined in the earthworm toxicity tests. No effects on earthworm survival were observed below 334 mg/kg. Although adverse effects on earthworms were observed in two soil samples with copper concentrations below 334 mg/kg (e.g. SAR-71-SS05 and SAR-69-SS11, with copper concentrations of 62.2 and 90 mg/kg, respectively), these soil samples exhibited elevated concentrations of lead (779 and 41,300 mg/kg, respectively) and the observed adverse effect on earthworms (reduced growth) was likely attributable to the elevated lead concentrations in these samples and not to the copper. An Eco-RBRG for copper set at the LOEC for earthworm survival and the AET for earthworm growth (334 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for copper of 334 mg/kg could result in growth effects on earthworms from residual copper in soil, and potentially affect the quality of the food resources for invertivores.

An Eco-RBRG for lead in soil can be identified as 760 mg/kg, based on earthworm growth. The lead concentration in soil of 760 mg/kg represents the NOEC for earthworm growth determined in the earthworm toxicity tests. No effects on earthworm survival or growth were observed at lead concentrations less than 760 mg/kg. An Eco-RBRG for lead set at the NOEC for earthworm growth (760 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC.

Table 4-2

**Surface Soil COPEC Concentrations and Earthworm Toxicity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama**

Sample Name	Sample ID	Antimony Conc. in Surface Soil (mg/kg - dry wt.)	Copper Conc. in Surface Soil (mg/kg - dry wt.)	Lead Conc. in Surface Soil (mg/kg - dry wt.)	Zinc Conc. in Surface Soil (mg/kg - dry wt.)	Toxicity Test Endpoints		
						14-Day Earthworm Survival (percent)	28-Day Earthworm Survival (percent)	Earthworm Growth (% wt. change)
ARTIFICIAL LABORATORY SOIL	ABC CONTROL							
HR-70Q-SS01-SS-RW0001-REG	RW0001	92.2	509	10600	139	100	24	87
SAR-85-SS37-SS-RW0002-REG	RW0002	187	711	22600	116	80	0	100
SAR-85-SS34-SS-RW0004-REG	RW0004	112	508	14900	128	100	96	49
SAR-71-SS05-SS-RW0005-REG	RW0005	ND	62.2	779	35.1	98	82	55
SAR-71-SS09-SS-RW0006-REG	RW0006	ND	34.9	480	39.3	100	100	-23
LMBC-REF1-SS-RW0007-REG	RW0007	ND	5.91	16.5	18.3	98	98	-8
LMBC-REF2-SS-RW0008-REG	RW0008	ND	4.25	38.3	19.2	100	100	-10
LMBC-REF3-SS-RW0009-REG	RW0009	ND	7.66	94.4	22.6	100	100	-23
HR-77Q-SS01-SS-RW0010-REG	RW0010	276	3580	20100	281	0	0	100
SAR-78-SS34-SS-RW0012-REG	RW0012	72.9	1200	15600	153	62	2	99
SAR-77-SS33-SS-RW0013-REG	RW0013	35.4	908	6860	72.8	36	0	100
HR-80Q-MW02-SS-RW0014-REG	RW0014	39.5	127	4660	43.9	98	98	-20
SAR-77-SS50-SS-RW0015-REG	RW0015	ND	14.6	156	19.9	100	100	-22
MMBC-REF-SS-RW0016-REG	RW0016	ND	5.86	39.4	20.3	98	98	-17
SAR-85-SS17-SS-RW0017-REG	RW0017	63.3	334	6820	73.1	96	65	67
SAR-78-SS25-SS-RW0018-REG	RW0018	298	2280	23100	229	0	0	100
SAR-78-SS17-SS-RW0019-REG	RW0019	17.9	393	2310	63.9	73	2	99
SAR-69-SS11-SS-RW0021-REG	RW0021	1620	90	41300	47.3	94 ^a	96 ^a	37
SAR-85-SS02-SS-RW0022-REG	RW0022	ND	93.1	180	71.5	98	96	-16
HMBC-REF-RW0023-REG	RW0023	ND	15.2	49.9	39.6	100	100	-16
SAR-70-SS12-SS-RW0024-REG	RW0024	ND	22.3	142	33.5	92	98	-19
HR-80Q-GP06-SS-RW0025-REG	RW0025	ND	56.2	486	28.1	100	100	-18
SAR-77-SS16-SS-RW0026-REG	RW0026	6.71	61.4	760	27.1	98	98	-20

 - Significant difference in survival or weight change between reference sites and on-site samples.

^a - 8 living worms were found on day-14 and 9 living worms were found on day-28 of the toxicity test. One living worm was apparently missed when counting day-14 survival rates.

An Eco-RBRG for zinc in soil can be identified as 72.8 mg/kg, based on earthworm growth. The zinc concentration in soil of 72.8 mg/kg represents the AET for earthworm growth determined in the earthworm toxicity tests. An Eco-RBRG for zinc set at the AET for earthworm growth (72.8 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC. However, because the earthworm growth LOEC for zinc is 35.1 mg/kg, it is important to recognize the possibility that an Eco-RBRG for zinc of 72.8 mg/kg could result in survival and/or growth effects on earthworms from residual zinc in soil, and potentially affect the quality of the food resources for invertivores.

The following values were identified as the Eco-RBRGs for soil COPECs, based on the results of the terrestrial invertebrate toxicity tests:

- Antimony: 17.9 mg/kg
- Copper: 334 mg/kg
- Lead: 760 mg/kg
- Zinc: 72.8 mg/kg.

4.2 Soil Ecological Risk-Based Remedial Goals Based on Terrestrial Food Web Interactions

The higher trophic level feeding guilds at FTMC were assessed in the IMR/BGR BERA (Shaw, 2008) via a terrestrial food web model. The natural history data for the terrestrial food web model feeding guilds are presented in Table 4-3, and the TRVs for mammalian and avian receptors are presented in Tables 4-4 and 4-5, respectively. An important component in the estimation of the ecological hazards from exposures to the COPECs in soils (antimony, copper, lead, and zinc) is the estimation of the bioaccumulation of COPECs from soil to terrestrial invertebrates. The relationship between the COPEC concentration in soil and the COPEC concentration in terrestrial invertebrate tissues is known as the soil-to-invertebrate bioaccumulation factor ($BAF_{\text{soil-to-invert}}$).

Table 4-3

Terrestrial Foodweb Model Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate ^d (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
White-Footed Mouse	<i>Peromyscus leucopus</i>	Omnivorous Mammal	1 (b)	0.0225 (b)	0.19 (a)	0.1237 (a)	0.00247 (a)	0.254 0.746	Terrestrial Invertebrates Terrestrial Vegetation
American Robin	<i>Turdus migratorius</i>	Omnivorous Bird	0.61 (a)	0.081 (a)	0.14 (a)	0.1816 (a)	0.00363 (c)	0.375 0.625	Terrestrial Invertebrates Terrestrial Vegetation
Short-Tailed Shrew	<i>Blarina brevicauda</i>	Invertivorous Mammal	0.964 (a)	0.0168 (a)	0.223 (a)	0.0899 (a)	0.00216 (a)	0.887 0.113	Terrestrial Invertebrates Terrestrial Vegetation
American Woodcock	<i>Scolopax minor</i>	Invertivorous Bird	61.3 (a)	0.169 (a)	0.1 (a)	0.1517 (a)	0.0158 (a)	0.950 0.050	Terrestrial Invertebrates Terrestrial Vegetation

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenhelder. *Mammals, Peterson Field Guide*.

c Assumed value based on soil ingestion values for other birds presented in USEPA (1993).

d Eco-RBRGs presented in Table 4-9 were calculated based on the assumption that soil/sediment ingestion was equal zero.

Soil ingestion rates (dry weight) were calculated using the following relationship: $IR_{soil} = IR_{food} \times Diet_{soil}$

where:

IR_{soil} = ingestion rate of soil (kg/kg/day, dry weight);

IR_{food} = food ingestion rate (kg/kg/day, dry weight); and

$Diet_{soil}$ = percentage of diet that is soil (percent).

Table 4-4

**Mammalian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama**

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents										
Antimony	Mouse	Longevity	1.25	10	0.125	5	1.25	1	1.25	5
Copper	Mink	Reproduction	12	1	12	1	15.4	1	15.4	1
Lead	Rat	Reproduction	8	1	8	2	80	1	80	2
Zinc	Mouse & Rat	Growth & Reproduction	104	10	10.4	3	320	1	320	4

NOTES :

- 1) Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano, 1982. "Effects of Supplemental Dietary Copper on Growth, Reproductive Performance, and Kit Survival of Standard Dark Mink and the Acute Toxicity of Copper to Mink." *Journal of Animal Science*, Vol. 55, pp. 337-343.
- 2) Azar, A. H.J. Trochimowicz, and M.E. Maxwell, 1973. "Review of Lead Studies in Animals Carried Out at Haskell Laboratory: Two-Year Feeding Study and Response to Hemorrhage Study." In: *Environmental Health Aspects of Lead: Proceedings, International Symposium*. D. Barth, et al., eds. Commission of European Communities, pp. 199-210.
- 3) Maita, K., M. Hirano, K. Mitsumori, K. Takabashi, and Y. Shirasu, 1981. "Subacute Toxicity Studies with Zinc Sulfate in Mice and Rats." *Journal of Pesticide Science*, Vol. 6, pp. 327-336.
- 4) Schlicker, S.A. and D.H. Cox, 1968. "Maternal Dietary Zinc, and Development and Zinc, Iron, and Copper Content of the Rat Fetus." *J. Nutr.*, 95:: 287-294.
- 5) Schroeder, H.A., M. Mitchener, J.J. Balassa, M. Kanisawa, and A.P. Nason, 1968. "Zirconium, Niobium, Antimony, and Fluorine, in Mice: Effects on Growth, Survival, and Tissue Levels." *J. Nutr.*, 95: 95-101.

Table 4-5

**Avian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama**

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents										
Antimony	Red-winged Blackbird	Mortality	100	900	0.111	3	100	180	0.556	3
Copper	1-Day old chicks	Growth & Mortality	46.97	1	46.97	2	61.72	1	61.72	2
Lead	American Kestrel & Japanese Quail	Reproduction	3.85	1	3.85	5	11.3	1	11.30	1
Zinc	Leghorn hen	Reproduction	130.9	1	130.9	4	130.9	0.1	1310	4

NOTES :

- 1) Edens, F., W.E. Benton, S.J. Bursian, and G.W. Morgan, 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, *Coturnix coturnix japonica*." *Toxicol. Appl. Pharmacol.*, 38: 307-314.
- 2) Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus, 1960. "The Tolerance of Growing Chickens for Dietary Copper." *Poultry Science*, Vol. 39, pp. 713-719.
- 3) Schafer, E.W., W.A. Bowles, and J. Hurlbut, 1983. The Acute Oral Toxicity, Repellency, and Hazard Potential of 998 Chemicals to One or More Species of Wild and Domestic Birds. *Arch. Environ. Contam. Toxicol.* 12(3): 355-382. As cited in: Hazardous Substances Databank. January 1995.
- 4) Stahl, J.L., J.L. Greger, and M.E. Cook, 1990. "Breeding-Hen and Progeny Performance When Hens are Fed Excessive Dietary Zinc." *Poultry Science*, Vol. 69, pp. 259-263.
- 5) Pattee, O.H., 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Arch. Environ. Contam. Toxicol.*, 13: 213-218.

In order to define the relationship between soil concentrations and earthworm tissue concentrations of COPECs, the soil data and earthworm tissue data collected as part of the IMR/BGR BERA were plotted for each of the soil COPECs (antimony, copper, lead, and zinc) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of copper, lead, and zinc in soil and earthworm tissues fit the data best. The regressions for the $BAF_{\text{soil-to-invert}}$ are presented as Figures J-6-9 through J-6-12 in the IMR/BGR BERA. The data for antimony suggest that there are no regression equations that accurately represent the relationship between soil concentrations and earthworm tissue concentrations of antimony. Therefore, in order to estimate a site-specific relationship between soil and earthworm tissue concentrations of antimony, the seven pairs of soil and earthworm tissue samples that had detectable concentrations of antimony were used to estimate a $BAF_{\text{soil-to-invert}}$ for antimony. The best fit regression models of the natural log transformed data for copper, lead, and zinc represent the site-specific $BAF_{\text{soil-to-invert}}$ and are summarized in Table 4-6. The $BAF_{\text{soil-to-invert}}$ for antimony based on paired soil and earthworm tissue samples is also presented in Table 4-6.

Table 4-6. Site-Specific Soil-to-Invertebrate Bioaccumulation Factors

Surface Soil COPEC	Site-Specific Soil-to-Invertebrate BAF
Antimony	0.188 ^a
Copper	$y = 0.4673 x + 1.4266$
Lead	$y = 1.1088 x - 0.5168$
Zinc	$y = 0.321 x + 3.1208$

where: y = natural logarithm of terrestrial invertebrate tissue concentration
 x = natural logarithm of soil concentration.

^a Earthworm tissue concentrations of antimony were inversely correlated with associated soil concentrations of antimony. However, a BAF was estimated using the 7 paired soil and earthworm tissue samples.

An important consideration in the calculation of these regression models is the fact that, for lead, only data from soil samples exhibiting lead concentrations less than 2,310 mg/kg were used in the regression analysis. It was assumed that soil exhibiting lead concentrations greater than 2,310 mg/kg would adversely impact the endpoints established for the earthworm toxicity tests and that including these high soil concentrations in the regression only serves to skew the result. Eliminating these data points from the regression analysis provided better resolution in the range of data where the critical endpoints are most likely impacted (i.e. where NOAELs and LOAELs are established). The slope of the linear regression for the edited lead data is greater than the slope of the linear regression for the un-edited lead data; however, the correlation coefficient for

the edited data is greater than the correlation coefficient for the un-edited data and the y-intercept for the edited data is less than the y-intercept for the un-edited data. Therefore, within the range of the edited data, the lead $BAF_{\text{soil-to-invert}}$ values result in somewhat lower calculated earthworm tissue concentrations than the $BAF_{\text{soil-to-invert}}$ values from the un-edited data. If the entire data set (un-edited) were to be used to define a linear regression for the lead $BAF_{\text{soil-to-invert}}$, the estimated lead concentrations in soil invertebrates would be greater than those presented in the BERA.

These site-specific $BAF_{\text{soil-to-invert}}$ values were used in the terrestrial food web model in the IMR/BGR BERA (Shaw, 2008) to estimate the transfer of COPECs from surface soil to terrestrial invertebrates. The terrestrial food web model was subsequently used in conjunction with the site-specific $BAF_{\text{soil-to-invert}}$ values to estimate soil concentrations of COPECs that would result in hazard quotients (HQs) of one. These estimated soil concentrations (assuming all of the conservatism inherent in the food web model) based on an HQ equal to 1.0 are summarized below in Table 4-7. (Note: The IMR/BGR BERA [Shaw, 2008] utilized a $BAF_{\text{soil-to-invert}}$ value for antimony of 0.22, which was referenced from the USEPA Combustion Guidance [1999], not accounting for the moisture content of earthworms. This $BAF_{\text{soil-to-invert}}$ value for antimony is coincidentally very close to the site-specific antimony $BAF_{\text{soil-to-invert}}$ value estimated using paired soil and earthworm tissue data.)

Table 4-7. Soil Ecological Risk-Based Remedial Goals Based on Site-Specific Soil-to-Invertebrate Bioaccumulation Factors

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{\text{soil-to-invert}}$) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{\text{soil-to-invert}}$) (mg/kg)
White-Footed Mouse :		
- antimony	4.85	48.5
- copper	267	350
- lead	205	1,680
- zinc	1,500	145,000
American Robin :		
- antimony	2.95	14.8
- copper	850	1,140
- lead	55	147
- zinc	31,500	434,000
Short-Tailed Shrew :		
- antimony	6.85	68.5
- copper	820	1,185
- lead	100	800
- zinc	215	173,000

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific BAF _{soil-to-invert}) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific BAF _{soil-to-invert}) (mg/kg)
American Woodcock :		
- antimony	12.2	61
- copper	11,870	16,200
- lead	105.5	280
- zinc	46,500	550,000

A site-specific lead BAF_{soil-to-invert} value can also be estimated using the eighteen paired data sets for soil and earthworm tissue that had detectable concentrations of lead. These paired data sets yielded an average BAF_{soil-to-invert} value for lead of 0.839. If this value is used in the terrestrial food web model for the lead BAF_{soil-to-invert} value, then the Eco-RBRGs for lead, based on food web interactions, are the following:

Table 4-8. Soil Ecological Risk-Based Remedial Goals For Lead Based on Paired Soil and Earthworm Tissue Data

Receptor	Soil Lead Conc. Based on NOAEL TRV and HQ = 1.0 (Paired Data BAF _{soil-to-invert}) (mg/kg)	Soil Lead Conc. Based on LOAEL TRV and HQ = 1.0 (Paired Data BAF _{soil-to-invert}) (mg/kg)
White-footed Mouse	250	2,500
American Robin	59.7	176
Short-tailed Shrew	116	1,170
American Woodcock	123	361

These Eco-RBRGs for lead based on soil and earthworm tissue data pairs are within the range of Eco-RBRGs calculated for food web interactions using the site-specific BAF_{soil-to-invert} values based on regression equations, except for the LOAEL-based Eco-RBRG for the white-footed mouse. These calculated soil lead concentrations based on an HQ of 1.0 and site-specific BAF_{soil-to-invert} values can be considered soil Eco-RBRGs for the protection of the upper trophic level organisms expected to occur at the BGR and IMR Ranges at FTMC.

A number of factors (physical, chemical, and biological) are instrumental in determining the potential for bioaccumulation of soil COPECs into terrestrial invertebrate tissues. Studies have shown that cation exchange capacity, pH, organic carbon content, clay content, manganese oxide levels, and iron oxide levels all contribute to the potential bioavailability and bioaccumulation of metals in soils (Criel, et al., 2008 and Bradham, et al., 2006). There is some debate as to which soil property influences metal bioavailability the greatest, but it is generally agreed that many of

the soil properties are inter-correlated and it is difficult to identify a single soil property that influences metal bioavailability the greatest. Criel, et al. (2008) have shown that cation exchange capacity influences the bioavailability and bioaccumulation of copper the greatest, while Bradham, et al. (2006) have shown that pH influences the bioavailability and bioaccumulation of lead the greatest. What is clear from the scientific literature is that it is a combination of many of these soil properties acting in combination with one another that controls the bioavailability and bioaccumulation potential of metals in soil.

The implication of the impact of the various soil properties at the IMR and BGR ranges on the $BAF_{\text{soil-to-invert}}$ values is that the site-specific $BAF_{\text{soil-to-invert}}$ values were derived using soil collected at the IMR and BGR ranges at FTMC; therefore, the site-specific $BAF_{\text{soil-to-invert}}$ values take into account the inherent bioavailability of the soils at FTMC.

One potential source of uncertainty with regard to the derivation of the site-specific $BAF_{\text{soil-to-invert}}$ values is the fact that earthworms exposed to soils during the bioaccumulation testing conducted as part of the IMR/BGR BERA were not depurated prior to chemical analysis; thus potentially resulting in artificially high COPEC concentrations in the earthworm tissue samples and artificially high $BAF_{\text{soil-to-invert}}$ values. Normally, organisms used for bioaccumulation studies are allowed to depurate for a period of time (usually 24 hours) after their exposure period in order to allow for the organisms' gut contents to be cleared (depurated). Depuration of the test organisms prior to chemical analysis ensures that the chemical analysis performed on the test organisms' tissues does not include the contents of the organisms' gut. The fact that the earthworms were not depurated prior to chemical analysis introduces uncertainty into the derivation of site-specific $BAF_{\text{soil-to-invert}}$ values.

In order to mitigate some of the uncertainty in the site-specific $BAF_{\text{soil-to-invert}}$ values due to the lack of earthworm depuration, the terrestrial food web model can be modified to incorporate an incidental soil ingestion rate of zero. Changing the incidental soil ingestion rate to zero mitigates a portion of the affect of not depurating the earthworms prior to analysis by assuming the soil in the earthworms' guts accounts for the soil that would be incidentally ingested while foraging. The Eco-RBRGs that were derived using the terrestrial food web model, site-specific $BAF_{\text{soil-to-invert}}$ values, and zero incidentally ingested soil are summarized in Table 4-9.

Table 4-9. Soil Ecological Risk-Based Remedial Goals Based on Site-Specific Soil-to-Invertebrate Bioaccumulation Factors and Zero Incidental Soil Ingestion

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific BAF _{soil-to-invert}) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific BAF _{soil-to-invert}) (mg/kg)
White-Footed Mouse :		
- antimony	5.15	51.5
- copper	277	363
- lead	212	1733
- zinc	4300	NA
American Robin :		
- antimony	3.14	15.7
- copper	890	1190
- lead	56.5	151
- zinc	NA	NA
Short-Tailed Shrew :		
- antimony	7.37	73.7
- copper	950	1395
- lead	101	808
- zinc	235	NA
American Woodcock :		
- antimony	16.25	81
- copper	37500	53000
- lead	112	295
- zinc	NA	NA

NA – The terrestrial food web model and site-specific BAF_{soil-to-invert} values indicate that zinc does not pose a hazard to these receptors.

These values could be considered Eco-RBRGs for soil COPECs based on food web interactions.

4.3 Recommended Soil Ecological Risk-Based Remedial Goals

As presented in the above discussions and summarized in Tables 4-2, 4-7, 4-8, and 4-9, the potential Eco-RBRGs for soil COPECs cover a wide range of values, depending on the measurement endpoint considered. The following sections discuss the soil COPECs and the recommended Eco-RBRGs for each soil COPEC.

4.3.1 Ecological Risk-Based Remedial Goal for Antimony in Soil

As summarized in Table 4-1, the Eco-RBRGs for antimony in soil range from 2.95 to 1,620 mg/kg. The Eco-RBRGs derived using the terrestrial food web model have a significant degree of uncertainty because the bioaccumulation studies conducted as part of the IMR/BGR BERA did not indicate a strong correlation between soil concentrations of antimony and earthworm

tissue concentrations of antimony. Therefore, the site-specific $BAF_{\text{soil-to-invert}}$ values have a significant degree of uncertainty associated with them. However, if the soil-earthworm paired data sets are used to estimate the antimony $BAF_{\text{soil-to-invert}}$ value, and the incidental soil ingestion rate is set to zero, the Eco-RBRGs for antimony in soil, based on terrestrial food web interactions, range from 3.14 mg/kg to 81 mg/kg. An Eco-RBRG set below the lowest LOAEL-based value of 15.7 mg/kg (Table 4-9) would be protective of all of the terrestrial food web measurement endpoints.

The strongest data set with regard to drawing correlations between antimony in soil and observed adverse impacts in biota is the earthworm survival data. No impacts were observed in the earthworm growth test that could be attributed to antimony. Adverse impacts to earthworm growth were observed at antimony concentrations as low as 17.9 mg/kg, which is the LOEC for earthworm survival. No adverse effects were observed at antimony concentrations less than 17.9 mg/kg. The earthworm survival AET is more than 1,620 mg/kg, which is significantly higher than the LOEC (17.9 mg/kg). It is difficult to resolve the adverse effects due to antimony because the soil samples with elevated antimony concentrations also have elevated copper and lead concentrations. Although reduced earthworm survival was recorded in the soil sample with an antimony concentration of 17.9 mg/kg, this same sample had a copper concentration of 393 mg/kg and a lead concentration of 2,310 mg/kg. It is likely that the observed adverse affect was due to the copper and/or lead in the soil sample and not antimony. Therefore, the recommended Eco-RBRG for antimony in soil is 17.9 mg/kg (which for ease in reporting is rounded to 18 mg/kg). This recommended Eco-RBRG for antimony is also very close to the LOAEL-based Eco-RBRG derived using site-specific $BAF_{\text{soil-to-invert}}$ value and the terrestrial food web model.

4.3.2 Ecological Risk-Based Remedial Goal for Copper in Soil

The Eco-RBRGs for copper in soil range from 61.4 to 16,200 mg/kg, depending upon the specific endpoint considered (Table 4-1). The terrestrial food web model-derived Eco-RBRGs range from 277 to 53,000 mg/kg (assuming a site-specific $BAF_{\text{soil-to-invert}}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor for copper in the terrestrial food web model is the omnivorous mammal (white-footed mouse). The calculated Eco-RBRGs for copper in soil based on terrestrial food web interactions of omnivorous mammals range from 277 to 363 mg/kg (Table 4-9). Because an Eco-RBRG based on the most sensitive endpoint would also be protective of all the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of

the terrestrial food web endpoints. Therefore, an Eco-RBRG for copper in soil within the range of 277 to 363 mg/kg would be protective of the terrestrial food web endpoints.

The Eco-RBRGs for copper in soil based on terrestrial invertebrate toxicity test results range from 61.4 mg/kg (earthworm growth NOEC) to 509 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equations for copper concentrations in soil and adverse effects observed in earthworms. These correlations are presented in Figures J-6-2 and J-6-6 in the IMR/BGR BERA (Shaw, 2008). The correlation coefficient for copper in soil and earthworm survival was estimated to be $r = 0.83$, and the correlation coefficient for copper in soil and earthworm growth was estimated to be $r = 0.88$. An Eco-RBRG based on the earthworm survival LOEC and earthworm growth AET (334 mg/kg) would be protective of most terrestrial invertebrate endpoints. Based on the earthworm toxicity testing results, copper concentrations in soil less than 334 mg/kg would not induce any adverse effects on earthworm survival. However, copper concentrations as low as 62.2 mg/kg (earthworm growth LOEC) in soil may induce adverse effects on earthworm growth. It is difficult to resolve the adverse effects due to copper because the soil samples with elevated copper concentrations also have elevated antimony and lead concentrations. Although reduced earthworm survival and growth were recorded in the soil sample with a copper concentration of 334 mg/kg, this same sample had an antimony concentration of 63.3 mg/kg and a lead concentration of 6,820 mg/kg. It is possible that the observed adverse effect was due to the antimony and/or lead in the soil sample and not to copper. In fact, if the earthworm growth LOEC for lead is 779 mg/kg, then it is likely that the lead (6,820 mg/kg) in the sample used to characterize the earthworm survival LOEC for copper is a causative agent for a significant portion of the observed toxicity.

Therefore, a reasonable Eco-RBRG for copper in soil is 334 mg/kg. Copper concentrations at or below 334 mg/kg in soil are unlikely to induce adverse effects on earthworm survival and would be protective of all of the endpoints for the receptors assessed via food web interactions. For these reasons, the recommended Eco-RBRG for copper in soil is 334 mg/kg. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for copper of 334 mg/kg could result in growth effects on earthworms from residual copper in soil, and potentially affect the quality of the food resources for invertivores.

4.3.3 Ecological Risk-Based Remedial Goal for Lead in Soil

The Eco-RBRGs for lead in soil range from 55 to 15,600 mg/kg (Table 4-1), depending upon the specific endpoint considered. The terrestrial food web model-derived Eco-RBRGs for lead in soil range from 56.5 to 1,733 mg/kg (assuming a site-specific $BAF_{\text{soil-to-invert}}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor in the terrestrial food web model for lead is the omnivorous bird (American robin). The calculated Eco-RBRGs for lead in soil based on terrestrial food web interactions of omnivorous birds range from 56.5 to 151 mg/kg (Table 4-9). Because an Eco-RBRG based on the most sensitive endpoint would also be protective of the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of the terrestrial food web endpoints. Therefore, an Eco-RBRG within the range of 56.5 to 151 mg/kg would be protective of the terrestrial food web endpoints.

The Eco-RBRGs for lead in soil, based on terrestrial invertebrate toxicity test results, range from 760 mg/kg (earthworm growth NOEC) to 15,600 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equation for lead concentrations in soil and earthworm growth ($r = 0.78$), while a somewhat weaker correlation is described by the regression equation for lead concentrations in soil and earthworm survival ($r = 0.66$). These correlations are presented on Figures J-6-3 and J-6-7 in the IMR/BGR BERA (Shaw, 2008). An Eco-RBRG for lead based on the earthworm growth NOEC (760 mg/kg) would be protective of all of the terrestrial invertebrate endpoints and is very close to the earthworm growth LOEC (779 mg/kg). Based on the earthworm toxicity testing results, lead concentrations in soil less than 760 mg/kg would not induce any adverse effects on earthworm survival or growth. Unlike the other soil COPECs, the adverse effects observed at a lead concentration of 760 mg/kg are likely attributable to lead, because the concentrations of the other soil COPECs are relatively low.

In order to collect empirical data for the purpose of determining potential risk to song birds at lead contaminated firing ranges, Mark Johnson, et al. (2007) conducted a study whereby blood-lead samples were collected from a number of bird species at 2 different small arms range complexes and compared them to a blood-lead TRV to determine if birds inhabiting these ranges were at risk from lead exposures. One of the range complexes studied was the Bains Gap Road (BGR) ranges at FTMC. The other range complex reported in this study was the Known Distance Range (KDR) at Aberdeen Proving Ground, MD. Blood-lead samples were collected from the following bird species at the BGR ranges: eastern bluebird (*Sialia sialis*), yellow-breasted chat (*Icteria virens*), indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*),

chipping sparrow (*Spizella passerina*), scarlet tanager (*Piranga olivacea*), eastern phoebe (*Sayornis phoebe*), brown thrasher (*Toxostoma rufum*), and downy woodpecker (*Picoides pubescens*). Surface soil samples were also collected from the BGR ranges and mean lead concentrations in surface soil ranged from 13,630 mg/kg in the target berm areas to 57 mg/kg in other areas. The 95% UCL lead concentration in soil for the study area at the BGR ranges was calculated to be 8,727 mg/kg. The blood-lead concentrations for birds sampled at the BGR ranges ranged from 1 to 25 µg/dL. These measured blood-lead concentrations were compared to literature-derived blood-lead TRVs of 29 µg/dL (NOAEL-based TRV) and 58 µg/dL (LOAEL-based TRV) in order to draw conclusions regarding the potential for risk. None of the measured blood-lead concentrations from the BGR ranges exceeded the blood-lead TRVs, indicating negligible risk to song birds at the BGR ranges from exposures to lead, even though the lead concentrations in soil at the BGR ranges were significantly elevated above background levels. These data indicate that a conservative bias is likely built into the terrestrial food web model for the IMR/BGR ranges due to the fact that desirable habitat at these ranges was limited at the time of sampling, and that the Eco-RBRGs that are derived using the terrestrial food web model are conservative, given the habitat restrictions that currently exist at the BGR ranges.

—A reasonable Eco-RBRG for lead in soil could be set at 760 mg/kg based on the earthworm toxicity test results. However, if terrestrial food web model interactions are also considered, the Eco-RBRG for lead in soil should be between 56.5 and 151 mg/kg. Empirical data from the BGR ranges suggest that an average concentration of lead in soil of 8,727 mg/kg may not pose risks to songbirds inhabiting the BGR ranges (Johnson, et al., 2007). An Eco-RBRG for lead in soil set at 500 mg/kg is lower than the Eco-RBRG protective of all the terrestrial invertebrate endpoints, and is also less than the soil concentration of lead shown to be protective of songbirds (the most sensitive food web receptor) currently inhabiting the BGR ranges. An Eco-RBRG for lead in soil of 500 mg/kg is likely protective of mammalian omnivores and mammalian invertivores through food web interactions; however, it is greater than the LOAEL-based Eco-RBRGs protective of avian invertivores and avian omnivores in the terrestrial food web model. Given the conservative nature of the terrestrial food web model, an Eco-RBRG for lead in soil of 500 mg/kg may also be protective of avian invertivores and avian omnivores. Therefore, the recommended Eco-RBRG for lead in soil is a “not to exceed value” of 500 mg/kg.

4.3.4 Ecological Risk-Based Remedial Goal for Zinc in Soil

The Eco-RBRGs for zinc in soil range from 33.5 to 555,000 mg/kg, depending upon the specific endpoint considered (Table 4-1). The terrestrial food web model-derived Eco-RBRGs for zinc in

soil range from 235 to unlimited (assuming a site-specific $BAF_{\text{soil-to-invert}}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor in the terrestrial food web model for zinc is the invertivorous mammal (short-tailed shrew). The calculated Eco-RBRGs for zinc in soil based on terrestrial food web interactions of invertivorous mammals range from 235 mg/kg to unlimited. Due to the nature of the site-specific $BAF_{\text{soil-to-invert}}$ value for zinc (very low slope), an upper bound on the range of Eco-RBRGs cannot be calculated. Several of the receptors in the terrestrial food web model are not sensitive to zinc exposures. Because an Eco-RBRG based on the most sensitive endpoint would also be protective of the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of the terrestrial food web endpoints. Therefore, an Eco-RBRG of 235 mg/kg would be expected to be protective of the terrestrial food web endpoints. Using the terrestrial food web model to derive Eco-RBRGs results in an extremely broad range of values, making it difficult to identify a single Eco-RBRG for zinc based on the terrestrial food web model.

The large range in food web-based Eco-RBRG values is due to the fact that the LOAEL-based TRV for zinc (320 mg/kg/day) is more than 30-times greater than the NOAEL-based TRV for zinc (10.4 mg/kg), and also the very flat slope of the site-specific $BAF_{\text{soil-to-invert}}$ regression equation. The very flat slope of the site-specific $BAF_{\text{soil-to-invert}}$ regression indicates that even a significant increase in soil concentration of zinc results in only a minimal increase in invertebrate tissue concentrations of zinc. These two factors combined, result in a broad range of food web-based Eco-RBRGs for zinc. Additionally, the Eco-RBRGs based on the terrestrial food web model are different than the Eco-SSLs (USEPA, 2007) for zinc for several reasons; namely, the Eco-SSLs assume different food ingestion rates, the Eco-SSLs assume different soil ingestion rates, the Eco-SSLs assume more simplified feeding strategies (i.e. mammalian invertivore consumes 100% earthworms), and the Eco-SSLs assume a different $BAF_{\text{soil-to-invert}}$ regression equation.

The zinc Eco-RBRGs based on terrestrial invertebrate toxicity test results range from 33.5 mg/kg (earthworm growth NOEC) to 139 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equations for zinc concentrations in soil and adverse effects observed in earthworms. These correlations are presented in Figures J-6-4 and J-6-8 in the IMR/BGR BERA (Shaw, 2008). The correlation coefficient for zinc in soil and earthworm survival was estimated to be $r = 0.78$, and the correlation coefficient for zinc in soil and earthworm growth was estimated to be $r = 0.83$. An Eco-RBRG based on the earthworm survival

and growth AETs (139 and 72.8 mg/kg, respectively) would be protective of most terrestrial invertebrate endpoints. Using the USEPA's "Rule of 5" (Greenberg and Charters, 2005), the geometric mean of these AET values results in a zinc concentration of 101 mg/kg. Based on the earthworm toxicity testing results and the "Rule of 5," zinc concentrations in soil greater than 100 mg/kg may induce adverse effects on earthworm growth and/or survival.

It is important to note that the adverse effects observed in the soil sample containing zinc at 72.8 mg/kg (earthworm growth AET) also had copper and lead concentrations of 908 and 6,860 mg/kg, respectively, and the soil sample containing zinc at 139 mg/kg (earthworm survival AET) also had copper and lead concentrations of 509 and 10,600 mg/kg, respectively. Therefore, it is likely that the observed adverse effects at 72.8 and 139 mg/kg zinc are at least partially due to the elevated copper and lead in these same soil samples. These elevated copper and lead concentrations make it difficult to resolve the zinc concentrations that may induce adverse effects. Therefore, a reasonable Eco-RBRG for zinc in soil is 100 mg/kg. Zinc concentrations at or below 100 mg/kg in soil would be protective of all of the sensitive endpoints for the receptors assessed via food web interactions. For these reasons, the recommended Eco-RBRG for zinc in soil is 100 mg/kg. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for zinc of 100 mg/kg could result in survival and/or growth effects on earthworms from residual zinc in soil, and potentially affect the quality of the food resources for invertivores.

Based on the lines of evidence presented in the previous sections, the recommended Eco-RBRGs for the soil COPECs are as follows:

- Antimony: 18 mg/kg
- Copper: 334 mg/kg
- Lead: 500 mg/kg
- Zinc: 100 mg/kg.

These values are recommended as "not-to-exceed" Eco-RBRGs for soil COPECs at the IMR and BGR Ranges at FTMC. If these recommended Eco-RBRGs are applied as "not-to-exceed" values, the average exposure levels for the soil COPECs would likely be lower, which would mitigate some of the uncertainties inherent in the derivation of the Eco-RBRGs.

5.0 Risk-Based Remedial Goals for Surface Water

Fathead minnow and ceriodaphnid toxicity tests conducted as part of the IMR/BGR BERA (Shaw, 2008) indicated that COPEC concentrations in surface water at the BGR Ranges may cause adverse effects in aquatic vertebrates (reduced fathead minnow survival and growth) and aquatic invertebrates (reduced ceriodaphnid survival and reproduction). The toxicity tests indicated that copper and lead were the most likely causative agents for the observed adverse effects in the surface water toxicity tests. Adverse effects were observed in fathead minnows and ceriodaphnids at copper concentrations as low as 0.0346 milligrams per liter (mg/L) and at lead concentrations as low as 0.00236 mg/L. Background screening values for copper and lead in surface water at FTMC have been established as 0.0127 mg/L for copper and 0.0087 mg/L for lead (IT, 2000).

The Eco-RBRGs for surface water COPECs at the IMR and BGR Ranges, based on fathead minnow survival and growth and ceriodaphnid survival and reproduction, ranged from 0.0129 to 0.0608 mg/L for copper and nondetectable to 0.0462 mg/L for lead. However, there is a significant level of uncertainty associated with a portion of the results of the ceriodaphnid survival test. The results of the ceriodaphnid toxicity testing indicate that seven-day survival rates were reduced in two surface water samples (SAR-77-SW19 and SAR-77-SW20), both of which exhibited nondetectable levels of copper and one of which had a nondetectable level of lead, and the other had a lead concentration of 0.00236 mg/L. Of the three samples that had concentrations of lead in the interval between sample SAR-77-SW20, which had 0.00236 mg/L lead, and sample SAR-78-SW12, which had 0.0306 mg/L lead, none of them induced any toxic effects: SAR-77-SW15, with 0.00357 mg/L lead; SAR-78-SW14, with 0.00762 mg/L lead; and SAR-78-SW13 with 0.0105 mg/L lead. The toxicity observed in SAR-77-SW20, with only 0.00236 mg/L lead, as well as the toxicity in SAR-77-SW19 with no detectable lead, was likely not due to lead, but other unknown factors. Copper similarly had lower levels in the same three samples than any of the other samples with observed toxicity except for SAR-77-12 and SAR-22-SW20, where copper was not detected. The available data are not conclusive as to the cause of the observed toxicity in samples SAR-77-SW19 and SAR-77-SW20. These toxicity test results indicate that a factor other than lead or copper in surface water may be the cause of reduced ceriodaphnid survival in these two samples.

Inclusion of the ceriodaphnid survival test results for samples SAR-77-SW19 and SAR-77-SW20 would indicate that survival is a more sensitive endpoint than reproduction. Because

reproduction is almost always a more sensitive endpoint than survival, it is counterintuitive and highly unlikely for the survival endpoints to be lower than the reproductive endpoints. If the ceriodaphnid survival results for these two samples (SAR-77-SW19 and SAR-77-SW20) are not considered further due to their uncertainty, then the results of the fathead minnow growth, ceriodaphnid survival, and ceriodaphnid reproduction tests are identical, as shown in Table 5-1.

Table 5-1. Surface Water Toxicity Test Results

Endpoint	Surface Water Copper Conc. (mg/L)	Surface Water Lead Conc. (mg/L)
Fathead Minnow Survival LOEC	0.0608	0.0462
Fathead Minnow Survival NOEC	0.0527	0.0422
Fathead Minnow Survival AET	0.0608	0.0462
Fathead Minnow Growth LOEC	0.0346	0.0306
Fathead Minnow Growth NOEC	0.0129	0.0105
Fathead Minnow Growth AET	0.0346	0.0306
Ceriodaphnid Survival LOEC	0.0346	0.00236
Ceriodaphnid Survival NOEC	0.0129	ND
Ceriodaphnid Survival AET	0.0346	0.0306
Ceriodaphnid Reproduction LOEC	0.0346	0.0306
Ceriodaphnid Reproduction NOEC	0.0129	0.0105
Ceriodaphnid Reproduction AET	0.0346	0.0306
Background Screening Values:	0.0127	0.00867
Surface Water Eco-RBRG Range :	0.0129 – 0.0608	ND – 0.0462

The surface water toxicity test results summarized above indicate that fathead minnow survival is the least sensitive endpoint and the other three endpoints (fathead minnow growth, ceriodaphnid survival, and ceriodaphnid reproduction) are identical. Therefore, if the most sensitive endpoint(s) are used to derive an Eco-RBRG, then the Eco-RBRG that is derived will also be protective of the other less sensitive endpoints.

In order to estimate a single Eco-RBRG for each constituent in surface water, the EPA's "Rule of 5" (Greenberg and Charters, 2005) was applied to the range of values calculated for the most sensitive assessment endpoints. By selecting the third progression node for the entire range between the lowest NOAEL and the lowest LOAEL for each assessment endpoint, the Eco-RBRG identified by the "Rule of 5" effectively is the same as calculating the geometric mean of these two values. Using this approach, the following Eco-RBRGs were estimated for surface water COPECs:

- Copper: 0.0211 mg/L
- Lead: 0.0179 mg/L.

These values are recommended for Eco-RBRGs for surface water COPECs at the IMR and BGR Ranges at FTMC. National and Alabama ambient water quality criteria (AWQC) should also be considered by risk managers as possible ecological remedial goals for surface water.

6.0 Risk-Based Remedial Goals for Sediment

Arsenic, barium, copper, lead, manganese, and thallium were identified as sediment COPECs in the SLERA conducted for the IMR and BGR Ranges and were assessed in the IMR/BGR BERA (Shaw, 2008). The sediment-related endpoints that were assessed in the IMR/BGR BERA were chironomid survival and growth, and modeled impacts to invertivorous mammals and birds through food web interactions. The results of the 10-day chironomid survival and growth test showed that growth (the most sensitive endpoint) was statistically reduced in sediment samples with copper concentrations as low as 10.4 mg/kg and lead concentrations as low as 76.7 mg/kg (Table 6-1). Arsenic, barium, and manganese concentrations in sediment were poorly correlated to the sediment toxicity test results, and thallium was not detected in any of the sediment samples collected for toxicity testing; therefore, these constituents were not considered causative agents in the observed adverse effects in the chironomid toxicity tests. Background screening values for copper and lead in sediment at FTMC have been established as 17.1 mg/kg for copper and 37.8 mg/kg for lead (IT, 2000).

The results of the riparian food web model indicated that there is a potential risk to riparian invertivorous mammals and riparian invertivorous birds from food web exposures to copper and lead in sediment. None of the other COPECs in surface water or sediment (arsenic, barium, manganese, and thallium) indicated the potential for adverse affects from food web exposures. The natural history parameters for the riparian food web model receptors are presented in Table 6-2. The riparian food web model was used to predict sediment concentrations that would be protective of the sensitive riparian feeding guilds found at the IMR and BGR Ranges. The riparian food web model indicated that adverse effects to riparian receptors could be expected at copper concentrations as low as 169 mg/kg and lead concentrations as low as 12.4 mg/kg in sediment (Shaw, 2008) (Table 6-1).

Table 6-1. Sediment Toxicity Test and Food Web Model Results

Endpoint	Sediment Copper Conc. (mg/kg)	Sediment Lead Conc. (mg/kg)
Benthic Invertebrate Survival and Growth:		
Chironomid Survival NOEC	126	495
Chironomid Survival LOEC	160	605
Chironomid Survival AET	380	>1,730
Chironomid Growth NOEC	9.06	23.1
Chironomid Growth LOEC	10.4	76.7

Endpoint	Sediment Copper Conc. (mg/kg)	Sediment Lead Conc. (mg/kg)
Chironomid Growth AET	74.9	432
Riparian Food Web Exposures:		
Invertivorous Mammal NOAEL	175	66
Invertivorous Mammal LOAEL	287	1,290
Invertivorous Bird NOAEL	99	3.1
Invertivorous Bird LOAEL	169	12.4
Background Screening Values:	17.1	37.8
Sediment Eco-RBRG Range :	9.06 – 380	3.1 – 1,730

The calculated Eco-RBRGs for sediment COPECs and all of the assessment endpoints assessed at the IMR and BGR ranges ranged from 9.06 to 380 mg/kg for copper and from 3.1 to 1,730 mg/kg for lead. It is important to note that these sediment Eco-RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of the IMR/BGR BERA (Shaw, 2008).

Utilizing the same methodology as was used to identify Eco-RBRGs for soil and surface water as described above, the sediment Eco-RBRGs are all less than the ESVs and background screening values for sediment at FTMC. Because it is unlikely that the Army would be required to remediate sediment to levels below naturally occurring background levels, an alternative approach to identifying appropriate Eco-RBRGs was sought.

Numerical sediment quality guidelines (SQG) for freshwater ecosystems have previously been developed using a variety of approaches. Each approach has certain advantages and limitations which influence their application in the assessment of sediment quality. In an effort to focus on the agreement among these various published SQGs, consensus-based SQGs were developed by MacDonald, et al., (2000) for 28 chemicals in freshwater sediments. For each chemical, two consensus-based SQGs were developed from the published SQGs: a threshold effect concentration (TEC); and a probable effect concentration (PEC). The TEC is the concentration of a chemical in sediment below which harmful effects are unlikely to be observed, and the PEC is the concentration of a chemical in sediment above which harmful effects are likely to be observed. The range of chemical concentrations between the TEC and the PEC represents chemical concentrations that have an unknown probability of eliciting adverse effects.

The consensus-based TECs and PECs for the COPECs in sediment (copper and lead) at the IMR and BGR Ranges are reported by MacDonald, et al., (2000) and listed in Table 6-3.

Table 6-2

Riparian Foodweb Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Area Use Factor (unitless)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
Little Brown Bat	<i>Myotis lucifugus</i>	Invertivorous Mammal	40 (c)	0.5	0.0080 (b)	0.16 (e)	0.0699 (d)	NA	1.0	Aquatic Emergent Invertebrates
Marsh Wren	<i>Cistothorus palustris</i>	Invertivorous Bird	0.13 (a)	1.0	0.01038 (a)	0.27 (a)	0.1833 (a)	NA	1.0	Aquatic Emergent Invertebrates

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.

c University of Michigan, 2006. *Spatial Foraging Habits of the Little Brown Bat (*Myotis lucifugus*) and Northern Long-Eared Bat (*Myotis septentrionalis*)*.

d Anthony and Kunz, 1977. Feeding Strategies of the Little Brown bat, *Myotis lucifugus*, in Southern New Hampshire.

e Sample, et al., 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.

Table 6-3. Consensus-Based Sediment Quality Guidelines

	Copper	Lead
Consensus-Based TEC	31.6 mg/kg	35.8 mg/kg
Consensus-Based PEC	149 mg/kg	128 mg/kg

In order to identify a single Eco-RBRG for each COPEC in sediment, the geometric mean of the consensus-based TEC and PEC for each COPEC was calculated. The geometric means of the TEC and PEC for copper and lead were calculated to be the following:

- Copper: 69 mg/kg
- Lead: 68 mg/kg.

The recommended Eco-RBRG for copper in sediment (69 mg/kg) is protective of all the chironomid endpoints that are greater than the background screening value and all of the riparian food web endpoints. The recommended Eco-RBRG for lead in sediment (68 mg/kg) is protective of all the chironomid endpoints that are greater than the background screening value and all of the riparian food web endpoints that are greater than the background screening value. If the Eco-RBRGs are set at concentrations greater than the background screening values, then the proposed Eco-RBRGs will be protective of the endpoints assessed in the BERA for the IMR and BGR ranges.

Therefore, the recommended Eco-RBRGs for copper and lead in sediment are as follows:

- Copper: 69 mg/kg
- Lead: 68 mg/kg.

7.0 References

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ATTACHMENT 1

LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene	ASP	Ammunition Supply Point	CAA	Clean Air Act
4-ADNT	4-amino-2,6-dinitrotoluene	ASR	Archives Search Report	CAB	chemical warfare agent breakdown products
2,4-D	2,4-dichlorophenoxyacetic acid	AST	aboveground storage tank	CACM	Chemical Agent Contaminated Media
2,4,5-T	2,4,5-trichlorophenoxyacetic acid	ASTM	American Society for Testing and Materials	CAIS	chemical agent identification set
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid	AT	averaging time	CAMU	corrective action management unit
3D	3D International Environmental Group	atm-m ³ /mol	atmospheres per cubic meter per mole	CBR	chemical, biological, and radiological
AB	ambient blank	ATSDR	Agency for Toxic Substances and Disease Registry	CCAL	continuing calibration
AbB3	Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded	ATV	all-terrain vehicle	CCB	continuing calibration blank
AbC3	Anniston gravelly clay loam, 6 to 10 percent slopes, severely eroded	AUF	area use factor	CCV	continuing calibration verification
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded	AWARE	Associated Water and Air Resources Engineers, Inc.	CD	compact disc
ABLM	adult blood lead model	AWQC	ambient water quality criteria	CDTF	Chemical Defense Training Facility
Abs	skin absorption	AWWSB	Anniston Water Works and Sewer Board	CEHNC	U.S. Army Engineering and Support Center, Huntsville
ABS	dermal absorption factor	'B'	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
AC	hydrogen cyanide	BAF	bioaccumulation factor	CERFA	Community Environmental Response Facilitation Act
ACAD	AutoCadd	BAF _{soil-to-invert}	soil-to-invertebrate bioaccumulation factor	CESAS	Corps of Engineers South Atlantic Savannah
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded	BBGR	Baby Bains Gap Road	CF	chloroform
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded	BCF	blank correction factor; bioconcentration factor	CF	conversion factor
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded	BCT	BRAC Cleanup Team	CFC	chlorofluorocarbon
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded	BERA	baseline ecological risk assessment	CFDP	Center for Domestic Preparedness
ACGIH	American Conference of Governmental Industrial Hygienists	BEHP	bis(2-ethylhexyl)phthalate	CFR	Code of Federal Regulations
ACM	asbestos-containing material	BFB	bromofluorobenzene	CG	phosgene (carbonyl chloride)
AdE	Anniston and Allen stony loam, 10 to 25 percent slope	BFE	base flood elevation	CGI	combustible gas indicator
ADEM	Alabama Department of Environmental Management	BFM	bonded fiber matrix	ch	inorganic clays of high plasticity
ADPH	Alabama Department of Public Health	BG	Bacillus globigii	CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
AEC	U.S. Army Environmental Center	BGR	Bains Gap Road	CIH	Certified Industrial Hygienist
AEDA	ammunition, explosives, and other dangerous articles	bgs	below ground surface	CK	cyanogen chloride
AEL	airborne exposure limit	BHC	hexachlorocyclohexane	cl	inorganic clays of low to medium plasticity
AET	adverse effect threshold; apparent effects threshold	BHHRA	baseline human health risk assessment	Cl	chlorinated
AF	soil-to-skin adherence factor	BIRTC	Branch Immaterial Replacement Training Center	CLP	Contract Laboratory Program
AHA	ammunition holding area	bkg	background	cm	centimeter
AL	Alabama	bls	below land surface	CN	chloroacetophenone
ALARNG	Alabama Army National Guard	BOD	biological oxygen demand	CNB	chloroacetophenone, benzene, and carbon tetrachloride
ALAD	δ-aminolevulinic acid dehydratase	Bp	soil-to-plant biotransfer factors	CNS	chloroacetophenone, chloropicrin, and chloroform
ALDOT	Alabama Department of Transportation	BRAC	Base Realignment and Closure	CO	carbon monoxide
amb.	Amber	Braun	Braun Intertec Corporation	CO ₂	carbon dioxide
AMEC	AMEC Earth & Environmental, Inc.	BSAF	biota-to-sediment accumulation factors	Co-60	cobalt-60
amsl	above mean sea level	BSC	background screening criterion	CoA	Code of Alabama
ANAD	Anniston Army Depot	BSV	background screening values	COC	chain of custody; chemical of concern
ANOVA	Analysis of Variance	BTAG	Biological Technical Assistance Group	COE	Corps of Engineers
AOC	area of concern	BTEX	benzene, toluene, ethyl benzene, and xylenes	Con	skin or eye contact
AOI	area of investigation	BTOC	below top of casing	COPC	chemical of potential concern
AP	armor piercing	BTV	background threshold value	COPEC	constituent of potential ecological concern
APEC	areas of potential ecological concern	BW	biological warfare; body weight	CPOM	coarse particulate organic matter
APT	armor-piercing tracer	BZ	breathing zone; 3-quinuclidinyl benzilate	CPSS	chemicals present in site samples
AR	analysis request	C	ceiling limit value	CQCSM	Contract Quality Control System Manager
ARAR	applicable or relevant and appropriate requirement	Ca	carcinogen	CRDL	contract-required detection limit
AREE	area requiring environmental evaluation	CaCO ₃	calcium carbonate	CRL	certified reporting limit
AS/SVE	air sparging/soil vapor extraction			CRQL	contract-required quantitation limit

List of Abbreviations and Acronyms (Continued)

CRZ	contamination reduction zone	DS2	Decontamination Solution Number 2	FBI	Family Biotic Index
Cs-137	cesium-137	DSERTS	Defense Site Environmental Restoration Tracking System	FD	field duplicate
CS	ortho-chlorobenzylidene-malononitrile	DWEL	drinking water equivalent level	FDC	Former Decontamination Complex
CSEM	conceptual site exposure model	E&E	Ecology and Environment, Inc.	FDA	U.S. Food and Drug Administration
CSM	conceptual site model	EB	equipment blank	Fe ⁺³	ferric iron
CT	central tendency	EBC	Eastern Bypass Corridor	Fe ⁺²	ferrous iron
CT	carbon tetrachloride	EBS	environmental baseline survey	FedEx	Federal Express, Inc.
ctr.	container	EBV	EBV Explosives Environmental Co.	FEMA	Federal Emergency Management Agency
CWA	chemical warfare agent; Clean Water Act	EC ₂₀	effects concentration for 20 percent of a test population	FFCA	Federal Facilities Compliance Act
CWM	chemical warfare materiel; clear, wide mouth	EC ₅₀	effects concentration for 50 percent of a test population	FFE	field flame expedient
CX	dichloroformoxime	ECBC	Edgewood Chemical Biological Center	FFS	focused feasibility study
'D'	duplicate; dilution	Eco-RGRG	ecological risk-based remedial goal	FI	fraction of exposure
D&I	detection and identification	Eco-SSL	ecological soil screening level	Fil	filtered
DA	Department of the Army	ED	exposure duration	Flt	filtered
DAAMS	depot area agent monitoring station	EDD	electronic data deliverable	FMDC	Fort McClellan Development Commission
DAF	dilution-attenuation factor	EF	exposure frequency	FML	flexible membrane liner
DANC	decontamination agent, non-corrosive	EDQL	ecological data quality level	f _{oc}	fraction organic carbon
°C	degrees Celsius	EE/CA	engineering evaluation and cost analysis	FOMRA	Former Ordnance Motor Repair Area
°F	degrees Fahrenheit	Eh	oxidation-reduction potential	FOST	Finding of Suitability to Transfer
DCA	dichloroethane	Elev.	elevation	Foster Wheeler	Foster Wheeler Environmental Corporation
DCE	dichloroethene	EM	electromagnetic	FR	Federal Register
DD	Defense Department	EMI	Environmental Management Inc.	Frtn	fraction
DDD	dichlorodiphenyldichloroethane	EM31	Geonics Limited EM31 Terrain Conductivity Meter	FS	field split; feasibility study; fuming sulfuric acid
DDE	dichlorodiphenyldichloroethene	EM61	Geonics Limited EM61 High-Resolution Metal Detector	FSP	field sampling plan
DDT	dichlorodiphenyltrichloroethane	EOD	explosive ordnance disposal	ft	feet
DEH	Directorate of Engineering and Housing	EODT	explosive ordnance disposal team	ft/day	feet per day
DEHP	di(2-ethylhexyl)phthalate	EPA	U.S. Environmental Protection Agency	ft/ft	feet per foot
DEP	depositional soil	EPC	exposure point concentration	ft/yr	feet per year
DFTPP	decafluorotriphenylphosphine	EPIC	Environmental Photographic Interpretation Center	FTA	Fire Training Area
DI	deionized	EPRI	Electrical Power Research Institute	FTMC	Fort McClellan
DID	data item description	EPT	Ephemeroptera, Plecoptera, Trichoptera	FTRRA	FTMC Reuse & Redevelopment Authority
DIMP	di-isopropylmethylphosphonate	ER	equipment rinsate	g	gram
DM	dry matter; adamsite	ERA	ecological risk assessment	g/m ³	gram per cubic meter
DMBA	dimethylbenz(a)anthracene	ER-L	effects range-low	G-856	Geometrics, Inc. G-856 magnetometer
DMMP	dimethylmethylphosphonate	ER-M	effects range-medium	G-858G	Geometrics, Inc. G-858G magnetic gradiometer
DNAPL	dense nonaqueous-phase liquid	ESE	Environmental Science and Engineering, Inc.	GAF	gastrointestinal absorption factor
DNT	dinitrotoluene	ESL	ecological screening level	gal	gallon
DO	dissolved oxygen	ESMP	Endangered Species Management Plan	gal/min	gallons per minute
DOD	U.S. Department of Defense	ESN	Environmental Services Network, Inc.	GB	sarin (isopropyl methylphosphonofluoridate)
DOJ	U.S. Department of Justice	ESV	ecological screening value	gc	clay gravels; gravel-sand-clay mixtures
DOT	U.S. Department of Transportation	ET	exposure time	GC	gas chromatograph
DP	direct-push	EU	exposure unit	GCL	geosynthetic clay liner
DPDO	Defense Property Disposal Office	Exp.	Explosives	GC/MS	gas chromatograph/mass spectrometer
DPT	direct-push technology	EXTOXNET	Extension Toxicology Network	GCR	geosynthetic clay liner
DQO	data quality objective	E-W	east to west	GFAA	graphite furnace atomic absorption
DRMO	Defense Reutilization and Marketing Office	EZ	exclusion zone	GFCI	ground fault circuit interruptor
DRO	diesel range organics	FAR	Federal Acquisition Regulations	GIS	Geographic Information System
DS	deep (subsurface) soil	FB	field blank	gm	silty gravels; gravel-sand-silt mixtures

List of Abbreviations and Acronyms (Continued)

gp	poorly graded gravels; gravel-sand mixtures	IF	ingestion factor; inhalation factor	LUCAP	land-use control assurance plan
gpm	gallons per minute	ILCR	incremental lifetime cancer risk	LUCER	land-use control effectiveness report
GPR	ground-penetrating radar	IMPA	isopropylmethyl phosphonic acid	LUCIP	land-use control implementation plan
GPS	global positioning system	IMR	Iron Mountain Road	m	meter
GRA	general response action	in.	inch	m/yr	meters per year
GS	ground scar	Ing	ingestion	max	maximum
GSA	General Services Administration; Geologic Survey of Alabama	Inh	inhalation	MB	method blank
GSBP	Ground Scar Boiler Plant	IP	ionization potential	MBB	Mohr's Barbara's buttons
GSSI	Geophysical Survey Systems, Inc.	IPS	International Pipe Standard	MCL	maximum contaminant level
GST	ground stain	IR	ingestion rate	MCLG	maximum contaminant level goal
GW	groundwater	IRDMIS	Installation Restoration Data Management Information System	MCPA	4-chloro-2-methylphenoxyacetic acid
gw	well-graded gravels; gravel-sand mixtures	IRIS	Integrated Risk Information Service	MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
H&S	health and safety	IRP	Installation Restoration Program	MCS	media cleanup standard
HA	hand auger	IS	internal standard	MD	matrix duplicate
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)	ISCP	Installation Spill Contingency Plan	MDA	Calhoun County McClellan Development Authority
HCl	hydrochloric acid	IT	IT Corporation	MDC	maximum detected concentration
HD	distilled mustard (bis-[dichloroethyl]sulfide)	ITEMS	IT Environmental Management System™	MDCC	maximum detected constituent concentration
HDPE	high-density polyethylene	ITRC	Interstate Trade and Regulatory Council	MDL	method detection limit
HE	high explosive	IWWP	installation-wide work plan	MEC	munitions and explosives of concern
HEAST	Health Effects Assessment Summary Tables	'J'	estimated concentration	MeV	mega electron volt
Herb.	herbicides	JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded	mg	milligrams
HHRA	human health risk assessment	JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded	mg/kg	milligrams per kilogram
HI	hazard index	JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes	mg/kg/day	milligram per kilogram per day
HN	hydrogen mustard	JPA	Anniston-Calhoun County Fort McClellan Development Joint Powers Authority	mg/kgbw/day	milligrams per kilogram of body weight per day
H ₂ O ₂	hydrogen peroxide	K	conductivity	mg/L	milligrams per liter
HPLC	high-performance liquid chromatography	K _d	soil-water distribution coefficient	mg/m ³	milligrams per cubic meter
HNO ₃	nitric acid	kg	kilogram	mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
HQ	hazard quotient	KeV	kilo electron volt	MHz	megahertz
HQ _{screen}	screening-level hazard quotient	K _{oc}	organic carbon partitioning coefficient	µg/g	micrograms per gram
hr	hour	K _{ow}	octanol-water partition coefficient	µg/kg	micrograms per kilogram
HRC	hydrogen releasing compound	KMnO ₄	potassium permanganate	µg/L	micrograms per liter
HSA	hollow-stem auger	L	liter; Lewisite (dichloro-[2-chloroethyl]sulfide)	µmhos/cm	micromhos per centimeter
HSDB	Hazardous Substance Data Bank	L/kg/day	liters per kilogram per day	min	minimum
HTRW	hazardous, toxic, and radioactive waste	l	liter	MINICAMS	miniature continuous air monitoring system
'I'	out of control, data rejected due to low recovery	LAW	light anti-tank weapon	ml	inorganic silts and very fine sands
IASPOW	Impact Area South of POW Training Facility	lb	pound	mL	milliliter
IATA	International Air Transport Authority	LBP	lead-based paint	mm	millimeter
ICAL	initial calibration	LC	liquid chromatography	MM	mounded material
ICB	initial calibration blank	LCS	laboratory control sample	MMBtu/hr	million Btu per hour
ICP	inductively-coupled plasma	LC ₅₀	lethal concentration for 50 percent population tested	MNA	monitored natural attenuation
ICRP	International Commission on Radiological Protection	LD ₅₀	lethal dose for 50 percent population tested	MnO ₄ ⁻	permanganate ion
ICS	interference check sample	LEL	lower explosive limit	MOA	Memorandum of Agreement
ID	inside diameter	LOAEL	lowest-observed-adverse-effects-level	MOGAS	motor vehicle gasoline
IDL	instrument detection limit	LOEC	lowest-observable-effect-concentration	MOUT	Military Operations in Urban Terrain
IDLH	immediately dangerous to life or health	LRA	land redevelopment authority	MP	Military Police
IDM	investigative-derived media	LT	less than the certified reporting limit	MPA	methyl phosphonic acid
IDW	investigation-derived waste	LUC	land-use control	MPC	maximum permissible concentration
IEUBK	Integrated Exposure Uptake Biokinetic			MPM	most probable munition

List of Abbreviations and Acronyms (Continued)

MQL	method quantitation limit	NRT	near real time	Pest.	pesticides
MR	molasses residue	ns	nanosecond	PETN	pentaerythritoltetranitrate
MRL	method reporting limit	N-S	north to south	PFO	palustrine forested wetland
MS	matrix spike	NS	not surveyed	PFT	portable flamethrower
mS/cm	millisiemens per centimeter	NSA	New South Associates, Inc.	PG	professional geologist
mS/m	millisiemens per meter	nT	nanotesla	PID	photoionization detector
MSD	matrix spike duplicate; minimum separation distance	nT/m	nanoteslas per meter	PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes
MTBE	methyl tertiary butyl ether	NTU	nephelometric turbidity unit	PM	project manager
msl	mean sea level	nv	not validated	POC	point of contact
MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes, severely eroded	O ₂	oxygen	POL	petroleum, oils, and lubricants
mV	millivolts	O ₃	ozone	POTW	publicly owned treatment works
MW	monitoring well	O&G	oil and grease	POW	prisoner of war
MWI&MP	Monitoring Well Installation and Management Plan	O&M	operation and maintenance	PP	peristaltic pump; Proposed Plan
Na	sodium	OB/OD	open burning/open detonation	ppb	parts per billion
NA	not applicable; not available	OD	outside diameter	ppbv	parts per billion by volume
NAD	North American Datum	OE	ordnance and explosives	PPE	personal protective equipment
NAD83	North American Datum of 1983	oh	organic clays of medium to high plasticity	ppm	parts per million
NaMnO ₄	sodium permanganate	OH•	hydroxyl radical	PPMP	Print Plant Motor Pool
NAVD88	North American Vertical Datum of 1988	ol	organic silts and organic silty clays of low plasticity	ppt	parts per thousand
NAS	National Academy of Sciences	OP	organophosphorus	PR	potential risk
NCEA	National Center for Environmental Assessment	ORC	Oxygen Releasing Compound	PRA	preliminary risk assessment
NCP	National Contingency Plan	ORP	oxidation-reduction potential	PRG	preliminary remediation goal
NCRP	National Council on Radiation Protection and Measurements	OSHA	Occupational Safety and Health Administration	PS	chloropicrin
ND	not detected	OSWER	Office of Solid Waste and Emergency Response	PSS	palustrine scrub/shrub wetland
NE	no evidence; northeast	OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector	PSSC	potential site-specific chemical
ne	not evaluated	OWS	oil/water separator	pt	peat or other highly organic silts
NEW	net explosive weight	oz	ounce	PVC	polyvinyl chloride
NFA	No Further Action	PA	preliminary assessment	QA	quality assurance
NG	National Guard	PAH	polynuclear aromatic hydrocarbon	QA/QC	quality assurance/quality control
NGP	National Guardsperson	PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity	QAM	quality assurance manual
ng/L	nanograms per liter	Parsons	Parsons Engineering Science, Inc.	QAO	quality assurance officer
NGVD	National Geodetic Vertical Datum	Pb	lead	QAP	installation-wide quality assurance plan
Ni	nickel	PBMS	performance-based measurement system	QC	quality control
NIC	notice of intended change	PC	permeability coefficient	QST	QST Environmental, Inc.
NIOSH	National Institute for Occupational Safety and Health	PCB	polychlorinated biphenyl	qty	quantity
NIST	National Institute of Standards and Technology	PCDD	polychlorinated dibenzo-p-dioxins	Qual	qualifier
NLM	National Library of Medicine	PCDF	polychlorinated dibenzofurans	QuickSilver	QuickSilver Analytics, Inc.
NO ₃	nitrate	PCE	perchloroethene	R	rejected data; resample; retardation factor
NOEC	no-observable-effect-concentration	PCP	pentachlorophenol	R ²	coefficient of determination
NPDES	National Pollutant Discharge Elimination System	PDS	Personnel Decontamination Station	R&A	relevant and appropriate
NPW	net present worth	PEC	probable effect concentration	RA	remedial action
No.	number	PEF	particulate emission factor	RAO	remedial action objective
NOAA	National Oceanic and Atmospheric Administration	PEL	permissible exposure limit	RBC	risk-based concentration; red blood cell
NOAEL	no-observed-adverse-effects-level	PEM	palustrine emergent wetland	RBP	Rapid Bioassessment Protocol
NR	not requested; not recorded; no risk	PERA	preliminary ecological risk assessment	RBRG	risk-based remedial goal
NRC	National Research Council	PERC	perchloroethene	RCRA	Resource Conservation and Recovery Act
NRCC	National Research Council of Canada	PES	potential explosive site	RCWM	Recovered Chemical Warfare Material
NRHP	National Register of Historic Places			RD	remedial design

List of Abbreviations and Acronyms (Continued)

RDX	cyclotrimethylenetrinitramine	SMDP	Scientific Management Decision Point	TCL	target compound list
ReB3	Rarden silty clay loams	s/n	signal-to-noise ratio	TCLP	toxicity characteristic leaching procedure
REG	regular field sample	SO ₄ ⁻²	sulfate	TDEC	Tennessee Department of Environment and Conservation
REL	recommended exposure limit	SOD	soil oxidant demand	TDGCL	thiodiglycol
RFA	request for analysis	SOP	standard operating procedure	TDGCLA	thiodiglycol chloroacetic acid
RfC	reference concentration	SOPQAM	U.S. EPA's <i>Standard Operating Procedure/Quality Assurance Manual</i>	TEA	triethylaluminum
RfD	reference dose	sp	poorly graded sands; gravelly sands	TEC	threshold effect concentration
RG	remedial goal	SP	submersible pump	TeCA	1,1,2,2-tetrachloroethane
RGO	remedial goal option	SPCC	system performance calibration compound	Tetryl	trinitrophenylmethylnitramine
RI	remedial investigation	SPCS	State Plane Coordinate System	TERC	Total Environmental Restoration Contract
RINRMP	Revised Integrated Natural Resources Management Plan	SPM	sample planning module	TEU	Technical Escort Unit
RL	reporting limit	SQG	sediment quality guideline	THI	target hazard index
RME	reasonable maximum exposure	SQRT	screening quick reference tables	TIC	tentatively identified compound
ROD	Record of Decision	Sr-90	strontium-90	TLV	threshold limit value
RPD	relative percent difference	SRA	streamlined human health risk assessment	TN	Tennessee
RR	range residue	SRI	supplemental remedial investigation	TNB	trinitrobenzene
RRF	relative response factor	SRM	standard reference material	TNT	trinitrotoluene
RRSE	Relative Risk Site Evaluation	Ss	stony rough land, sandstone series	TOC	top of casing; total organic carbon
RSD	relative standard deviation	SS	surface soil	TPH	total petroleum hydrocarbons
RTC	Recruiting Training Center	SSC	site-specific chemical	TR	target cancer risk
RTECS	Registry of Toxic Effects of Chemical Substances	SSHO	site safety and health officer	TRADOC	U.S. Army Training and Doctrine Command
RTK	real-time kinematic	SSHHP	site-specific safety and health plan	TRPH	total recoverable petroleum hydrocarbons
RWIMR	Ranges West of Iron Mountain Road	SSL	soil screening level	TRV	toxicity reference value
SA	exposed skin surface area	SSSL	site-specific screening level	TSCA	Toxic Substances Control Act
SAD	South Atlantic Division	SSSSL	site-specific soil screening level	TSDF	treatment, storage, and disposal facility
SAE	Society of Automotive Engineers	STB	supertropical bleach	TSS	total suspended solids
SAIC	Science Applications International Corporation	STC	source-term concentration	TWA	time-weighted average
SAP	installation-wide sampling and analysis plan	STD	standard deviation	TYG	Tennessee yellow-eyed grass
SARA	Superfund Amendments and Reauthorization Act	STEL	short-term exposure limit	UCL	upper confidence limit
sc	clayey sands; sand-clay mixtures	STL	Severn-Trent Laboratories	UCR	upper certified range
Sch.	schedule	STOLS	Surface Towed Ordnance Locator System [®]	'U'	not detected above reporting limit
SCM	site conceptual model	Std. units	standard units	UIC	underground injection control
SD	sediment	SU	standard unit	UF	uncertainty factor
SDG	sample delivery group	SUXOS	senior UXO supervisor	UL	Underwriter's Laboratory
SDWA	Safe Drinking Water Act	SVOC	semivolatile organic compound	URF	unit risk factor
SDZ	safe distance zone; surface danger zone	SW	surface water	USACE	U.S. Army Corps of Engineers
SEMS	Southern Environmental Management & Specialties, Inc.	SW-846	U.S. EPA's <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods</i>	USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
SF	cancer slope factor	SWMU	solid waste management unit	USAEC	U.S. Army Environmental Center
SFSP	site-specific field sampling plan	SWPP	storm water pollution prevention plan	USAEHA	U.S. Army Environmental Hygiene Agency
SGF	standard grade fuels	SZ	support zone	USACMLS	U.S. Army Chemical School
Shaw	Shaw Environmental, Inc.	TAL	target analyte list	USAMPS	U.S. Army Military Police School
SHP	installation-wide safety and health plan	TAT	turn around time	USATCES	U.S. Army Technical Center for Explosive Safety
SI	site investigation	TB	trip blank	USATEU	U.S. Army Technical Escort Unit
SINA	Special Interest Natural Area	TBC	to be considered	USATHAMA	U.S. Army Toxic and Hazardous Material Agency
SL	standing liquid	TCA	trichloroethane	USC	United States Code
SLERA	screening-level ecological risk assessment	TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin	USCG	U.S. Coast Guard
sm	silty sands; sand-silt mixtures	TCDF	tetrachlorodibenzofurans	USCS	Unified Soil Classification System
SM	Serratia marcescens	TCE	trichloroethene	USDA	U.S. Department of Agriculture

List of Abbreviations and Acronyms (Continued)

USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance level; upper tolerance limit
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VC	vinyl chloride
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VQIfr	validation qualifier
VQual	validation qualifier
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
WAC	Women's Army Corps
Weston	Roy F. Weston, Inc.
WP	white phosphorus
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WWI	World War I
WWII	World War II
XRF	x-ray fluorescence
yd ³	cubic yards
ZVI	zero-valent iron

RESPONSE TO COMMENTS

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

**Response to ADEM Comments on the
Final-Revision 1, Identification of Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Alabama**

Comments from Stephen A. Cobb, Chief – Governmental Hazardous Waste Branch, Land Division, received in a letter dated 3/22/10.

Comment 1: **Table 4-1:** ADEM accepted these RBRGs during the December 2008 meeting at Fort McClellan, with the understanding that soil RBRGs in Section 4.0 are, or should be, identical to those presented in the BERA in the subject RI reports. Since the antimony values presented in this revised table differ from those presented in Table K-8-1 of the Final RI for Bains Gap Road and Table J-8-1 of the Final RI for Iron Mountain Road, please confirm that these finalized values are presented in all documents. Also, the potential RBRGs for soil are presented in Table J-8-1 of the Final RI for Iron Mountain Road, but, unlike Table K-8-1 of the Final RI for Bains Gap Road, the potential RBRGs for sediments and surface water are not presented. Please address.

Response 1: As stated in the Eco-RBRG white paper (page 4-10), the terrestrial food web model in the IMR/BGR BERA (Shaw, 2008) utilized the soil-to-invertebrate BAF value for antimony of 0.22 referenced from the USEPA *Combustion Guidance* (1999) without accounting for the moisture content of earthworms. During subsequent revisions of the Eco-RBRG white paper, the RI reports for both the IMR ranges and BGR ranges were finalized. The Eco-RBRGs for antimony in soil have subsequently been re-calculated using the site-specific soil-to-invertebrate BAF (0.188) derived from the paired soil and earthworm data collected during the IMR/BGR BERA. Revising the final RI reports for both the IMR ranges and BGR ranges would entail the revision of more than 30 tables and a number of pages of text in each of the RI reports and BERA appendices. Due to the level of effort, breadth of the revisions, and lack of resources required to revise the RI reports, the Army intends to leave the finalized RI reports un-changed and simply revise the Eco-RBRG white paper accordingly. To allay ADEM's concerns, the Army notes that the Eco-RBRGs presented in the white paper represent the most up-to-date Eco-RBRGs derived for FTMC and will be the values considered in subsequent tasks (e.g., feasibility studies) involving remedial actions at these sites.

Comment 2: **Page 4-5, Paragraph 1:** Please revise the last sentence to insert a clause clarifying the reason for the caveat: "However, *because the earthworm growth LOEC for zinc is 35.1 mg/kg*, it is important to recognize that..."

Response 2: The sentence will be revised as suggested in the comment.

Comment 3: Table 4-3: At EPA's request (Comment 2 dated October 21, 2009) and as discussed on page 4-12, the incidental soil ingestion rate for the American robin was reset to zero to calculate the RBRGs. However, Table 4-3 still presents an ingestion rate greater than zero. Please revise the table and clarify if the soil ingestion rate also was reset to zero for the American woodcock and either of the mammalian receptors

Response 3: Eco-RBRGs were initially estimated (Table 4-7) using the exposure parameters presented in Table 4-3. As requested by EPA, incidental soil ingestion was subsequently assumed to equal zero and additional Eco-RBRGs were also estimated for all of the terrestrial receptors assuming an incidental soil ingestion rate of zero and these Eco-RBRGs are summarized in Table 4-9. No changes in the text or tables are necessary.

Comment 4: Page 4-17, Section 4.3.3, 1st Paragraph: Please revise the first full sentence to indicate that the concentrations quoted from Johnson were mean concentrations of 13,630 mg/kg and 57 mg/kg in the target berm and other areas. Please also revise the fourth full sentence of this paragraph to more explicitly cite the avian blood lead TRV as a NOAEL of 29 µg/dL, not 29.5. Please also mention the blood lead LOAEL of 58 µg/dL cited by Johnson et al.

Response 4: The soil lead concentrations quoted from Johnson, et al., 2007 will be reported as mean concentrations. The text (p. 2219) of the Johnson et al. (2007) paper reports a NOAEL-based TRV of 29.5 µg/dL while the appendix of the same paper references a NOAEL-based TRV of 29 µg/dL. Given the variability in the derivation of these numbers, 29 µg/dL and 29.5 µg/dL are, in practice, the same number. However, the text will be revised to present a NOAEL-based TRV of 29 µg/dL and a LOAEL-based TRV of 58 µg/dL.

Comment 5: Page 4-17, Section 4.3.3, 2nd Paragraph: Please add discussions to provide additional context for the results of the Johnson study, including: (a) the observation made in EPA's Comment 9 (dated October 21, 2009), that these birds inhabited peripheral areas of the range outside the bulk of the contamination; (b) it, therefore, cannot be concluded that the blood lead levels of resident birds might not be higher if they were to nest and/or forage more frequently within "hot spot" portions of the range with much higher soil lead concentrations; and (c) a statement explaining that the bluebird with a blood lead level (25 µg/dL) closely approaching the NOAEL was a nestling so that it is conceivable that higher blood lead levels could occur in older birds after more prolonged exposures, especially if they nest/feed mostly in hot spots.

Response 5:

Figure 1 in Johnson, et al. (2007) suggests that the nest boxes that were used to collect samples of food items and blood samples from nestling birds are, in fact, within the areas of greatest lead contamination (target berms) at the Bains Gap Road ranges. Additionally, the mist nets used to capture singing males and nesting females were also set "in the proximity of nests and in areas primarily within the berms, firing points, and target areas." The assertion that the captured birds inhabited peripheral areas of the range outside the bulk of the contamination is not substantiated by the data presented in Johnson, et al. (2007). The Eco-RBRG white paper makes no conclusions regarding the possibility of blood lead levels being higher or lower for birds nesting or foraging in areas other than those sampled by Johnson, et al. (2007). The Eco-RBRG white paper simply reiterates the empirical data presented in Johnson, et al. (2007), as requested by ADEM. The fact that the blood level of a single nestling bluebird was close to the NOAEL cannot be used to substantiate the hypothesis presented in the comment. The data presented in Johnson, et al. (2007) show that "Blood-lead concentrations of nestlings were not different from adults," and to suggest otherwise is pure conjecture and is not supported by the data. No changes to the Eco-RBRG white paper are warranted.

Comment 6:

Page 4-18, Section 4.3.4, 2nd Paragraph: Please revise the next to last sentence in the second paragraph, which incorrectly states that "an Eco-RBRG within the range of 235 to unlimited would be expected to be protective..." ADEM disagrees with this conclusion since zinc very likely could become toxic to wildlife at a higher concentration that would result in a dietary ingestion exceedance of the zinc LOAEL of 320 mg/kgBW/day cited in the next paragraph. Please revise this discussion to indicate that an RBRG set at 235 mg/kg, which is above the soil BTV for zinc, would be protective of wildlife receptors.

Response 6:

The referenced statement presents the results of the site-specific terrestrial food web model and is accurate. However, the last 2 sentences of the 2nd paragraph will be revised as follows: "Therefore, an Eco-RBRG of 235 mg/kg would be expected to be protective of the terrestrial food web endpoints. Using the terrestrial food web model to derive Eco-RBRGs results in an extremely broad range of values, making it difficult to identify a single Eco-RBRG for zinc based on the terrestrial food web model."

Comment 7:

Section 5.0: Although ADEM accepted these RBRGs during the December 2008 meeting at Fort McClellan, it was agreed among ADEM, EPA, and the Army that if these RBRGs prove to be higher than national AWQC or Alabama AWQC, once adjusted using site-specific water hardness data, that the lower AWQC will supersede these RBRGs. Please add a closing statement to this section documenting this discussion and agreement from the meeting.

Response 7:

The following sentence will be added to the last paragraph in Chapter 5:
“National and Alabama ambient water quality criteria (AWQC) should also be considered by risk managers as possible ecological remedial goals for surface water.”

U.S. ENVIRONMENTAL PROTECTION AGENCY

**Response to EPA Comments on
Final-Revision 1, Identification of Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Alabama**

Comments from Sharon Thoms, Life Scientist, Technical Services Section, Superfund Support Branch, Superfund Division, received via e-mail on 4/8/10.

COMMENTS:

Comment 1: The changes made to the text addressed my previous comments. Text added to Section 4.3.2 Ecological Risk-based Remedial Goal for Lead in Soil on Page 4-17 to address a state comment included a sentence stating that "Empirical data from the BGR ranges suggests that an average concentration of lead in soil of 8,727 mg/kg does not pose risks to songbirds inhabiting the BGR ranges (Johnson *et al.*, 2007)." This comment is written because Johnson *et al.* (2007) do not state that there were no risks to songbirds at the BGR ranges. EPA disagrees that the blood lead levels in songbirds presented by Johnson *et al.* (2007) prove there were no risks to songbirds at the BGR ranges. The paper by Johnson *et al.* (2007) indicated lead exposure to birds at the BGR ranges. Concentrations of lead in blood ranged between 1 to 25 µg/dl (11 birds) at the BGR ranges, relative to the threshold value of 29.5 µg/dl. A similar paper for another firing range documented exposures to lead in birds and small mammals that also were typically below thresholds for adverse effects in captured birds and mammals (Lewis *et al.* 2001). However, Lewis *et al.* (2001) concluded that lead fragments were impacting wildlife at their firing ranges. Lewis *et al.* (2001) described elevated lead levels in liver and kidneys of birds and mammals found dead at the range. The Johnson *et al.* (2007) paper addresses spatially explicit exposure but does not give the full picture on potential impacts of bullet fragments at firing ranges to wildlife. Johnson *et al.* (2007) did not consider impacts to small mammals and did not sample weak or unhealthy birds that could not fly into mist nets or that had died. The white paper appears to imply that an average concentration of lead in soil of 8,727 mg/kg would not pose a risk to songbirds at the site. Because the Johnson *et al.* (2007) study was not conducted by the Base Closure Team as part of the risk assessment, the study can at most inform the risk managers of uncertainties about the conclusions of the BERA. The Johnson *et al.* (2007) study cannot be used to make a statement that there were no risks posed to songbirds by lead in soil at the BRG ranges. A statement that there were no risks at the ranges conflicts with conclusions presented by the Army in the BERA. Change the words "*does not*" to "*may not*" in the sentence.

Response 1: The wording in the sentence in question will be changed to "may not."

Comment 2: The response to comments did not include a response for EPA comment 8.

Response 2: The following response was provided for USEPA's Comment 8 in their previous round of comments.

Response to Comment 8: The recommended Eco-RBRG for lead in soil of 500 mg/kg will be recommended as a "not-to-exceed" value.

REFERENCES:

Johnson, M.S.; Wickwire, W.T.; Quinn, M.J.; Ziolkowski, D.J.; Burmistrov, D.; Menzie, C.A.; Geraghty, C.; Minnich, M.; and P.J. Parsons. 2007. Are songbirds at risk from lead at small arms ranges? An application of the spatially explicit exposure model. *Environ. Tox. Chem.* 26(10):2215-2225.

Lewis, L.A.; Poppenga, R.J.; Davidson, W.R.; Fischer, J.R.; and K.A. Morgan. 2001. Lead toxicosis and trace element levels in wild birds and mammals at a firearms training facility. *Arch. Environ. Contam. Toxicol.* 41: 208-214

U.S. EPA REGION IV

SDMS

Unscannable Material Target Sheet

DocID: 10860250

Site ID: AL0000408585

Site Name: Fort McEllen - Annapolis

Nature of Material:

Map:

☐

Computer Disks:

☐

Photos:

☐

CD-ROM:

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Blueprints:

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Oversized Report:

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Slides:

☐

Log Book:

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Other (describe): Final Review & Identification of
Ecological Risk-Based Remedial Goals

Amount of material: _____

* Please contact the appropriate Records Center to view the material *